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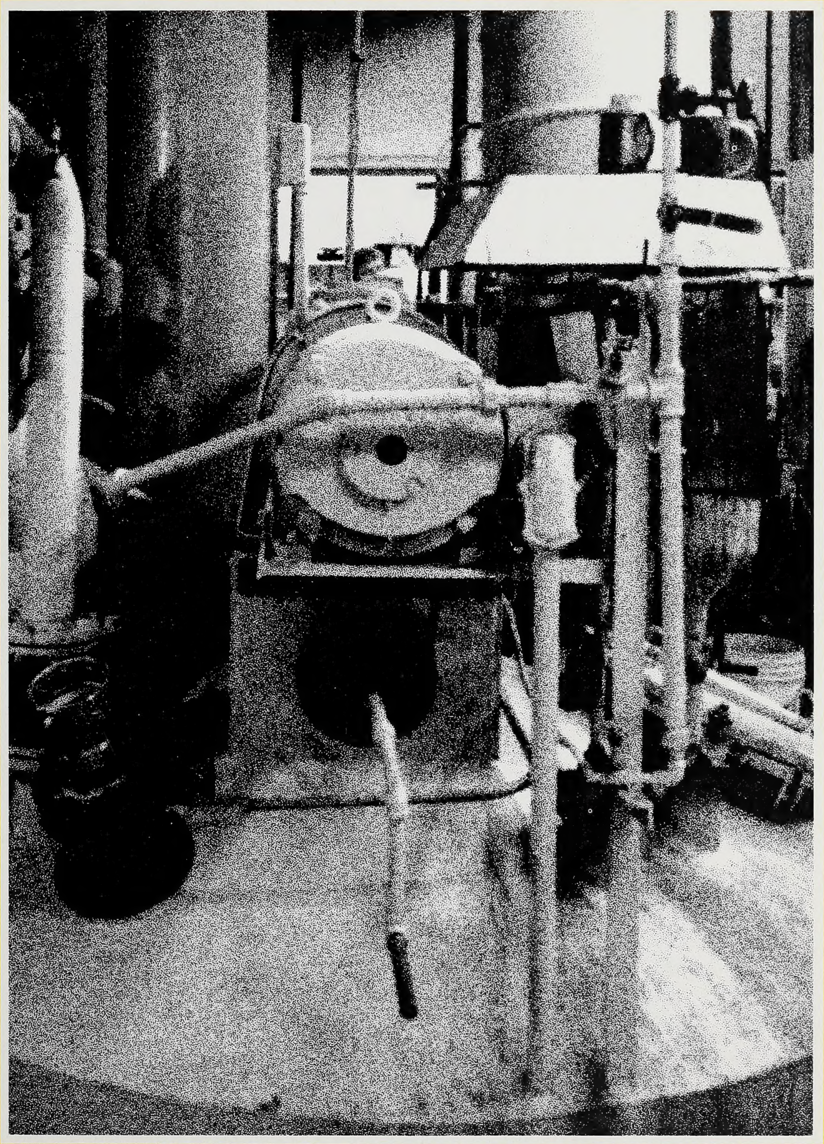
NON-COMMODITY CHEMICALS

Development Opportunities in Alberta



Alberta
ECONOMIC DEVELOPMENT
Manufacturing Industries
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NON-COMMODITY CHEMICALS

DEVELOPMENT OPPORTUNITIES IN ALBERTA

PREPARED FOR

DEPARTMENT OF ECONOMIC DEVELOPMENT

THE GOVERNMENT OF ALBERTA

BY

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APRIL 1984

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& Associates

Non-Commodity Chemicals:

Development Opportunities in Alberta

April, 1984

Table of Contents

Page

SECTION I - EXECUTIVE SUMMARY

1.1 Specialty chemical definitions 2
1.2 Specialty chemical selection criteria 3
1.3 Alberta's strengths in specialty chemicals 3
1.4 Chemicals with high potential for manufacture in Alberta 6

SECTION II - ALBERTA'S STRENGTHS IN NON-COMMODITY CHEMICALS

2.1 Nature of the regional economy 10
2.2 Specialty chemical markets in Alberta 12
2.3 Energy and raw materials in Alberta 13
2.4 Manufacturing input costs in the province 17
2.4.1 Personnel 17
2.4.2 Utilities 19
2.4.3 Plant regulations 21
2.4.4 Hazardous waste handling 21
2.5 Status of Alberta's infrastructure 22
2.6 Alberta's technical resources 23
2.7 Comparative costs for capital projects 25
2.8 Transportation factors 26

SECTION III - SELECTED NON-COMMODITY CHEMICALS

3.1.0 The manufacture of pesticides 32
3.1.1 Manufacture of chemicals for industrial explosives 32
3.1.2 Manufacture of industrial surfactants 32
3.1.3 Manufacture of other oilfield and mining specialties 33
3.1.4 Manufacture of engineering and like polymers 33
3.1.5 Manufacture of chemicals derived from waste streams 33

3.1.6 Manufacture of chemicals derived from sulfur 34
3.1.7 Manufacture of chemicals dervied from potash 34

3.2.0 Selective herbicides 35
3.2.1 The manufactured products 35
3.2.2 Alberta's strengths 38
3.2.3 Supply/demand balance 39
3.2.4 Major suppliers 41

3.3.0 Alkylamines and derivatives 43
3.3.1 The manufactured products 43
3.3.2 Alberta's strengths 46
3.3.3 Supply/demand balance 47
3.3.4 Major suppliers 48

3.4.0 Halogenated intermediates 49
3.4.1 The manufactured products 49
3.4.2 Alberta's strengths 53
3.4.3 Supply/demand balance 54
3.4.4 Major suppliers 55

3.5.0 Specialty products for explosives use 57
3.5.1 The manufactured products 57
3.5.2 Alberta's strengths 60
3.5.3 Supply/demand balance 60
3.5.4 Major suppliers 61

3.6.0 Other formaldehyde derivatives 63
3.6.1 The manufactured products 63
3.6.2 Alberta's strengths 65
3.6.3 Supply/demand balance 66
3.6.4 Major suppliers 67

3.7.0 Surfactants and oilfield chemicals 69
3.7.1 The manufactured products 69
3.7.2 Alberta's strengths 73
3.7.3 Supply/demand balance 74
3.7.4 Major suppliers 75

3.8.0 Derivatives of tall oil 77
3.8.1 The manufactured products 77
3.8.2 Alberta's strengths 80
3.8.3 Supply/demand balance 80
3.8.4 Major suppliers 81

3.9.0 Derivatives of ethylenediamine 83
3.9.1 The manufactured products 83
3.9.2 Alberta's strengths 85
3.9.3 Supply/demand balance 86
3.9.4 Major suppliers 87

3.10.0 Cellulosic water-soluble polymers 89
3.10.1 The manufactured products 89
3.10.2 Alberta's strengths 93
3.10.3 Supply/demand balance 93
3.10.4 Major suppliers 95

3.11.0 Other water soluble polymers 96
3.11.1 The manufactured products 96
3.11.2 Alberta's strengths 97
3.11.3 Supply/demand balance 98
3.11.4 Major suppliers 99

3.12.0 Polyvinyl alcohol and derivatives 101
3.12.1 The manufactured products 101
3.12.2 Alberta's strengths 103
3.12.3 Supply/demand balance 104
3.12.4 Major suppliers 104

3.13.0 Specialized styrenic products 106
3.13.1 The manufactured products 106
3.13.2 Alberta's strengths 110
3.13.3 Supply/demand balance 110
3.13.4 Major suppliers 111

3.14.0 Hydrocarbon resins 113
3.14.1 The manufactured products 113
3.14.2 Alberta's strengths 114
3.14.3 Supply/demand balance 115
3.14.4 Major suppliers 117

3.15.0 Sulfur compounds 118
3.15.1 The manufactured products 118
3.15.2 Alberta's strengths 121
3.15.3 Supply/demand balance 122
3.15.4 Major suppliers 123

3.16.0 Caustic potash and derivatives 125
3.16.1 The manufactured products 125
3.16.2 Alberta's strengths 127
3.16.3 Supply/demand balance 128
3.16.4 Major suppliers 129

3.17.0 Terpenes and other turpentine derivatives 130
3.17.1 The manufactured products 130
3.17.2 Alberta's strengths 132
3.17.3 Supply/demand balance 133
3.17.4 Major suppliers 135

3.18.0 Fermentation products 136
3.18.1 The manufactured products 136
3.18.2 Alberta's strengths 140
3.18.3 Supply/demand balance 141
3.18.3.1 Citric acid 143
3.18.3.2 Monosodium glutamate 144
3.18.3.3 Sorbitol 144
3.18.3.4 Ascorbic acid 145
3.18.3.5 Enzymes 147
3.18.4 Major suppliers 148

APPENDIX I - THE PROVINCE OF ALBERTA - A PROFILE

APPENDIX II - STATISTICS FOR CHEMICAL IMPORTS INTO CANADA DURING 1981 AND 1982

SECTION I

EXECUTIVE SUMMARY

This project has had, as an overall objective, the determination of the types of specialized chemical products that may justifiably be manufactured in Alberta and of the companies that could make the necessary investments. Recommendations are made on the premise that the global economies are increasingly reliant on the use of chemicals which modify or replace traditional materials. Much of society's innovative effort will be expended on developing products with specialized functions. The current emphasis on "downstream" investments by companies wedded to the manufacture of "commodity" chemicals supports such a premise.

When the Alberta Department of Economic Development decided to commission this research project, the terms of reference were to:

1. Assess Alberta's potential for hosting non-commodity chemical production.
2. Identify chemicals that could be profitably made in Alberta.
3. Recommend policies to promote non-commodity chemicals.

The approach taken by Law, Sigurdson & Associates was to assess the potential that the province held for non-commodity chemicals development in terms of its markets, potential raw materials and infrastructure.

We then screened more than 1,500 non-commodity chemicals and narrowed the study down to approximately 350 chemicals. Our final selection and analysis was carried out on some 110 chemicals that fell into 22 major groupings.

An analysis of specialty chemical imports was used as a starting point to determine domestic markets. Appendix II contains the chemicals and import figures considered in the initial selection.

In addition, critical to the development of non-commodity chemicals in Alberta is the attitude of the potential investors. Investor perceptions of Alberta, Canada and of the prospects for non-commodity chemicals development were obtained from interviews with 37 specialty and non-commodity chemical manufacturing companies in Canada, the United States and Europe.

1.1 Specialty chemical definitions

There is no universally accepted definition of what is meant by the term chemical specialty. The boundaries of this enquiry were therefore rather elastic, extending to emcompass chemical products perhaps better described as pseudo-commodities as well as the more highly differentiated proprietary or "performance" chemicals.

The so-called "fine chemicals", extremely pure and of relatively high value, have many of the attributes of commodities but yet are rightly within our purview. Excluded from evaluation were the bulk commodities (first and second derivatives of such base chemicals as ethylene and benzene) on one hand and the myriad of formulated products (coatings, adhesives, compounded herbicides, etc.) on the other. Some discussion of these excluded areas was, of course, necessary because the cost and availability of raw materials or the opportunities for utilizing a chemical in formulated products are often central to the prospects for manufacturing the specialty product in a given region.

For this project non-commodity chemicals were taken, as the overall scope for examination, to include the specialized intermediates, specialty and fine chemicals. This broad definition allowed for the grouping of both the intermediates and their downstream derivatives.

Very evident in the study is the correlation between the availability of various chemical intermediates (many of which are not yet produced in Alberta) and the prospects for successful manufacture of the downstream specialized chemicals.

1.2 Specialty chemical selection criteria

At least four basic criteria were applied to the consideration of potential investment in manufacturing facilities in the province.

* The manufacture of a chemical specialty must have the potential of being carried out on a cost competitive basis;

* The costs of transportation to likely customers and the level of custom's duty surmounted to gain access to those customers cannot be too onerous;

* The investor usually looks for both market growth and future price stability (the latter condition implies that he ought to be able to expect no great disparity between potential supply and demand);

* The investor, more often as not a multinational firm, must perceive any undertaking in Alberta as being consistent with his strategic objectives.

The opportunities to go downstream from the existing base of commodity chemicals and other raw materials (and from other derivatives likely to be manufactured in the province) are numerous. Such opportunities will require both time and fostering by the province if they are to be translated into actual investments. Yet it is usually the case that the initiation of one project creates more favorable conditions for others.

1.3 Alberta's strengths in specialty chemicals

The manufacturing economics relating to any product made in Alberta may depend on numerous factors. Alberta's major strengths lie in the availability of raw materials and in the infrastructure that has accompanied oil and gas as well as petrochemical development in the province. The most common question asked is whether or not the probable advantages in raw material costs for an Alberta producer can offset a variety of negative factors. The most important of these is the lack of a large local market for some of the products derived from these raw materials. The absence of such a local demand and the long transportation hauls to established markets will be an insurmountable problem for some non-commodity products. In other cases Alberta has enough compensating advantages to offset the penalty of distance or there is enough promise of consumption in the regional resource industries (oil and gas, mining, agriculture, etc.) to warrant an investment in manufacturing facilities.

For most of the specialized chemicals reviewed in the study the variable costs are relatively important (often from 30 to 50 percent of the selling price), which augurs well for a location where raw material and energy prices are attractive. Capital-related costs (depreciation, return on investment, maintenance and certain overheads) do constitute a significant fraction of the total, though they are substantially less if a pre-existing manufacturing site can be utilized. Construction costs in Alberta are now much more in line with those applying elsewhere in North America. Furthermore, any expenditures calculated in U.S. dollars have been reduced by the shift in the relative values of the two currencies.

Often the market-related factors -- transportation, custom duties, the world selling price, currency exchange rates and the profit margin available to cover research and development expenses -- are critical in making the decision to invest.

Rail transportation is an important cost element for just about any chemical product made in Alberta, the local market normally constituting only a small portion of total disposition of a plant's output. For almost any chemical product to be manufactured successfully in Alberta, the manufacturer will be seeking to export a portion of his output. Being contiguous to the U.S. should be a benefit for Canada, but tariff barriers do exist, the currencies differ (and political considerations are not to be neglected.)

In Alberta all the major inputs and services are readily available for non-commodity chemicals manufacture. Capital costs are comparable to other major chemical producton locations in North America. In addition, the province is investing $50 million in a hazardous waste treatment facility to serve the growing chemicals industry in the province.

With softness in the world economy and general over-supply conditions for most chemicals including specialties, companies are cautious about any "greenfield" investments today. During this study we found that companies feel cautious because of the size of the local or regional market for the products they manufacture. However, they are impressed by momentum created by the buildup of Alberta's petrochemical industry in recent years and have considered becoming part of it.

Alberta, as a province, probably will have to promote the development of specialty chemicals and perhaps a concerted policy initative will both attract the attention of potential investors and build a warmer climate for such investment.

The presence of a petrochemical base in Alberta does not by itself assure downstream development and whatever structure does emerge will take many years to fully evolve. Even the U.S. Gulf Coast did not automatically become, in the immediate post-war years, the magnet for the manufacture of specialties. Where the project was by its very nature an exploitation of an underutilized sidestream (i.e. by-product of a process intended in the main for other purposes), the site of that project is usually predetermined. But often it is easier to move the raw material to a preferred location (usually an established plant with a trained workforce and proximity to a customer base) than to duplicate an existing facility for no other reason that the second plant has an over-the-fence supply of the raw material.

The concept of industrial parks is certainly a valid one as is access to a central waste-disposal facility. Waste handling is a necessary part of the infrastructure for the production of higher organic reactions in the province. The commitment to build a $50-million hazardous waste treatment plant near Swan Hills ought to remove one more obstacle to additional investment in chemical manufacturing plants.

Policies and programs designed to encourage technological innovation in the province may not only lead to the manufacture of new products but also improve the general quality of the community of management and labor within Alberta. There is a modicum of provincially-supported research and development in the province. It could be extended to take into account some of the more promising lines of industrial development indicated in this report. For example, programs related to enhanced oil recovery or to the fermentation of agricultural wastes could be integrated into the mandates accorded existing research bodies.

1.4 Chemicals with high potential for manufacture in Alberta

It is our contention that the best opportunities relate to chemicals that can be derived from raw materials and/or intermediates for which Alberta can promise a long-term cost advantage -- if those chemicals fit reasonably well into market structure that has taken shape in western Canada, the western half of North America or, in relatively rare cases, the Pacific-Rim countries.

This study's emphasis on specialized chemicals for the resource industries (pesticides, explosives and other mining chemicals, oilfield chemicals, products for pulp and paper mills, water treatment) underlines the need to build on Alberta's natural strengths.

Perhaps the highest potential could be attached to the production of methylamines and derivatives (choline chloride, dimethyl formamide); hexamine, PETN and slurry/gel explosives; carboxymethyl cellulose; tall oil fatty acids; ethoxylated surfactants; polyglycols; sodium hydrosulfite and styrene polymers as products well suited for manufacture in Alberta.

Herbicides represent one of few markets where consumption patterns point to continued growth in demand. More farmers are employing broad-spectrum weed control, turning to "no-till" cultivation (which favors herbicides over tilling equipment) and to broadcast application of the various formulations. Infestation of fields with wild oats and broadleaf weeds is seemingly endemic to prairie agriculture. This same pattern applies to large sections of the northern-tier states south of the border so that the natural market area for any Alberta producers of herbicides is decidedly large.

Three major obstacles do stand in the way of a full-blown herbicide manufacturing industry in Canada. First, the potential investor faces tariffs on products leaving the country (particularly the U.S. duty) whereas his competitor located elsewhere can bring a similar pesticide into Canada duty free. Secondly, registrations of new products have become increasingly more difficult to obtain in North America. And finally, most of the key chemical intermediates required in the manufacture of herbicides are yet to be made in Alberta. (See Section 3.2 for a fuller discussion of herbicides. Sections 3.3 on alkylamines, 3.4 on halogenated products and 3.15 on mercaptans are also relevant to this subject.)

Explosives are already in wide use for coal and metal mining, oilwell shooting and construction in both western Canada and the U.S. states west of the Mississippi. The fact that the manufacture of most explosives are based on natural gas (via ammonium nitrate, hexamine, methyl amine and pentaerythritol) happily coincides with one of Alberta's greatest strengths. (See Section 3.5).

With **ethylene oxide** currently being manufactured in Alberta, sulfur (for sulfonation reactions) indigenous to the province and the prospect of several hydrophobes (alpha-olefins, fatty acids, etc.) being manufactured locally, the option of making **surface-active agents** for detergent and other purposes (wood pulping, petroleum demulsificiation, etc.) is becoming more attractive. If and when enhanced oil recovery creates a demand for **petroleum sulfonates** or other surfactants, regional markets for these surface-active agents will be broadened significantly. Related ethylene oxide derivatives relevant to Alberta's world position are certain **polyglycols** and possibly **ethylene diglycolamine** and **morpholine.** (See Section 3.7).

Also related to the resource industries are several products derived from **tall oil** (Sec 3.8), **ethylene diamine** (Sec 3.9), **acrylates, vinyl acetate** (Sec 3.12) and **cellulose.** Alberta **oilfield specialties** (including drilling muds and corrosion inhibitors) are formulated in the main from imported ingredients, including water-soluble polymers (See Sections 3.10 and 3.11).

The promise of even larger motor-vehicle, telecommunications and business-machine fabricating industries in California and in Pacific-Rim countries also suggests much increased demand for the so-called **engineering resins**. Though Alberta has no sophisticated plastics processing industry to speak of, it could provide some of the resins to processors in these other regions -- especially if they contain styrene, a monomer becoming available in Alberta. (See Section 3.13).

Large-scale chemical processing often results in the creation of waste streams that can be regarded as a nuisance (they must be buried or otherwise inactivated) or as a source of valuable chemicals. Kraft pulp mills must export recovered tall oil (See Section 3.8) and/or **turpentine** (Sec 3.17) to the U.S. The ethane crackers at Joffre have side streams which are currently burned as fuel or shipped unseparated to distant customers. The opportunity exists for the recovery of **hydrocarbon resins** (Sec 3.14) or for **chlorinated hydrocarbons** See Section 3.4). The refining of sugar beets yields a molasses that could be used for **fermentation products** (Sec 3.18) such as citric acid. A pentaerythritol plant generates sodium formate, which at present is destroyed using a catalyst but could be used for **amine derivatives** (Sec 3.3) or **sodium hydrosulfite** (Sec 3.15).

Several **sulfur products** are currently being produced in Alberta and perhaps more of the same could be manufactured profitably. Other derivatives such as **mercaptans** and **sulfites** may also fit into the Alberta environment (Sec 3.15).

The world's largest reserves of potash are next door to Alberta. Some of that potash could be upgraded to such **potassium chemicals** as potassium carbonate and potassium phosphate. (See Section 3.16).

SECTION II

ALBERTA'S STRENGTHS IN NON-COMMODITY CHEMICALS

The chemicals industry in Alberta began in the 1950's after major oil and gas fields were brought into production in the province. The growth of Western Canada along with this newly discovered resource provided the base for these investments. The availability and price of natural gas attracted plants producing polyethylene, formaldehyde, cellulose acetate, pentaerythritol and fertilizers.

During the 1960's the chemicals complex in the Fort Saskatchewan area took further shape as production of chlorine, ethylene glycol, ethanolamines and chlorinated phenols began.

During the 1970's Alberta became the home of an impressive industrial sector devoted to the manufacture of chemical products for world markets. The feedstock advantage, based particularly on ethane or natural gas, provided the impetus for this growth. Methanol plants were the first major petrochemical installations. By the late '70's the first ethylene plant was operating and the derivative plants had come onstream. Table 2.1 outlines the historical developmment of Alberta petrochemicals.

The annual value of shipments increased by an order of magnitude by 1981 to $1,349 million. Plants producing polyvinyl chloride, polyethylene glycol, ethylene dichloride, vinyl chloride and ethylene oxide all came onstream, fed by the world-scale ethylene plants in the province.

2.1 Nature of the regional economy

The economy of Alberta has been determined by its wealth of natural resources and the spread of its population (currently about 2.2 million people settled on 661,188 square kilometers of territory). Appendix I profiles the Alberta economy and the natural resources possessed by the province. Crude petroleum generated $8.25 billion worth of income for the province in 1981, natural gas taken out of the ground was valued at $5.7 billion, natural-gas liquids (NGL) totalled $2.36 billion and elemental sulfur, $675 million.

Coal is the mineral mined in the largest volumes in Alberta (other than oil and gas) and is also a growing industry in British Columbia (BC). The only other mining activity of note in Alberta is the processing of the Athabasca tar sands. Base-metal mining is significant in B.C. and to the east, Saskatchewan is a major producer of potash and uranium while Manitoba has zinc, copper, gold and nickel mining.

The southern portion of Alberta, part of the great western plains, is one of the most productive agricultural areas in the country. (The net value of agricultural production in 1981 was $2.6 billion.) Because of the proximity of crude oil production, oil refining -- three major refineries in the Edmonton area -- constitutes the largest single fraction of the manufacturing sector. Two large kraft pulp mills in the northwestern portion of the province helped make the forest products industry important to the Alberta economy (shipments of $575 million in 1981). A much larger forest industry exists in the B.C. interior and on the west coast.

Table 2.1

Alberta Petrochemical Developments Historically

Year	Company	Location	Products
1946	Cominco	Calgary	fertilizers
1952	Celanese Canada	Edmonton	formaldehyde, pentaerythritol
1953	C-I-L	Edmonton	polyethylene
1954	Sherritt Gordon Mines	Ft. Saskatchewan	fertilizers
1956	Western Co-Op Fertil.	Medicine Hat	fertilizers
1957	Borden Chemical	Edmonton	phenolic resins
1964	Dow	Ft. Saskatchewan	chloralkali, glycol
1965	Thio-Pet	Ft. Saskatchewan	carbon disulfide
1969	Esso Chemical	Redwater	fertilizers
1974	Cancarb	Medicine Hat	carbon black
1975	Alberta Gas Chemicals	Medicine Hat	methanol
1976	Canadian Fertilizers	Medicine Hat	fertilizers
1977	Cominco	Carseland	fertilizers
1977	C-I-L	Carseland	ammonium nitrate
1979	Dow	Ft. Saskatchewan	VCM, EO/EG, chloralkali
1979	Alberta Gas Ethylene	Joffre	ethylene
1980	Celanese	Edmonton	vinyl acetate
1981	Alberta Gas Chemicals	Medicine Hat	methanol
1982	Celanese	Edmonton	methanol
1983	Esso Chemical	Redwater	ammonia, urea
1983	Sherritt Gordon Mines	Ft. Saskatchewan	ammonia, urea

2.2 Specialty chemical markets in Alberta

A bias in favor of resource industries and a lack of population density has shaped the manufacture of chemical specialties in Alberta to date. Those establishments already located in the province concern themselves, in the main, with formulating products best supplied from a local point to the resources-oriented sectors of western Canada.

In this category are facilities blending herbicides, oilfield and water-treatment specialties, etc. The actual manufacture of the active ingredient has been almost always done elsewhere (either in eastern Canada, the United States or offshore) because economies of scale make the justification of a local manufacturing facility difficult.

There are a few exceptions. One Edmonton-area company makes resins for the forest product industries (plus urea-formaldehyde condensate as a urea fertilizer coating). Some xanthates are made from captive carbon disulfide for the western mining industry. Two Edmonton plants import various precursors to make a range of exotic organic chemicals and/or specialized polymers. The two most popular non-selective herbicidal chemicals, amines and esters of 2,4-dichlorophenoxyacetic acid (2,4-D) and of methyl chlorophenoxyacetic acid (MCPA) were manufactured in the Edmonton region until very recently.

The raw materials for non-commodity chemicals manufacturing coupled with the present service-oriented specialty chemicals markets in Alberta provide the business elements on which specialty chemicals manufacturing could be justified.

The major Alberta market areas are:

Agriculture - pesticides,
growth hormones,
animal feed supplements.

Oil & gas - surfactants,
drilling muds,
fracturing compounds.

Mining - flotation chemicals,
water treatment chemicals.
explosives

Pulp & paper - brightening agents,
paper additives,
sizes and coating resins,
water treatment chemicals.

Municipal - water treatment chemicals.

The agricultural market in Alberta, with its $3.8 billion in cash receipts and farm expenditures totalling $2.5 billion, form a substantial market base. Farmers in the province in 1981 spent over $250 million on fertilizers and $129 million on herbicides and other crop expenses.

In addition Alberta forms part of the Canadian prairie market where annual expenditures on herbicides come to some $300 million at the farm level, including emulsifiers, surfactants and other blending agents.

The oil and gas industry has been a major Alberta force over the past decade. Drilling activity, while down in recent months, had been running at over 5,000 wells drilled in the province annually for the past several years.

Production capabilities of Alberta as of 1981 showed a capacity of 20,000 oil and 22,600 gas wells, according to statistics from the Energy Resources Conservation Board. Alberta supplies 85 percent of Canadian crude needs and 90% of Canada's natural gas requirements. The province's more than 400 gas processing plants and oil wells provide a stable, growing market for a range of chemicals for process use and maintenance. In addition, the viability of secondary and tertiary recovery will probably open up further markets for chemicals in the oil and gas industry in the province in the coming years.

The regional market for non-commodity chemicals includes many of the mining chemicals, pulp and paper chemicals and some industrial products. CMC going into the potash industry in Saskatchewan is one example, and there are many others.

2.3 Energy and raw materials in Alberta

Feedstock costs for ethylene based chemical derivatives hold out the potential to be highly competitive in Alberta for years to come. Methane based chemicals such as methanol and ammonia should be similarily competitive.

Alberta has through economic position and domestic pricing been able to price commodity chemicals feedstocks in the province at a level to make the petrochemical plants world competitive. This Alberta edge is likely to remain for years to come and chemicals from the province will be exported into North American, European and Pacifc Rim countries.

Specialty chemical manufacture in Alberta will not consume a significant proportion of the output of the present world-scale petrochemical plants in the province. However, non-commodity chemical and intermediate plant development could provide a local outlet for some of the product from these large plants.

At worst the commodity chemical plants in the province should sell locally on a U.S. or other international price, less transportation and duty. The benefit of having a local, locked-in customer might induce some of the commodity chemical producers to offer raw material incentives to non-commodity chemical projects in the province.

Feedstocks will be an important consideration in non-commodity chemicals investment in Alberta and can provide an 'edge' in the plant economics. The overall justification for plants will likely be that, if the feedstocks are available, an Alberta manufacturing investment will involve identifying a sufficient western North American market to support the investment.

In Alberta there is a wide range of non-commodity chemical feedstocks available on a commodity basis. Alberta has the following products available as feedstocks for non-commodity chemicals:

Acetic acid/chloracetic acid
Ammonia
Benzene
Canola meal
Carbon disulfide
Caustic soda
Chlorine
Dissolving pulp

...continued/

Continued

Ethylene dichloride
Ethylene oxide
Formaldehyde
Hydrogen
Hydrogen chloride
Hydrogen sulfide
Methanol
Nitric acid
Pentaerythritol
Resin formers
Sodium sulfate (salt cake)
Styrene
Sugar beet sucrose and wastes
Sulfur
Sulfuric acid
Tall oil
Turpentine
Urea
Vinyl acetate
Wet-process phosphoric acid

In addition the petrochemical and petroleum refining operators in the province have unseparated streams containing further feedstock potential such as propylene, toluene, xylene, butadiene, etc. These streams could be processed should local demand exist for those products.

Side streams and effluents from the ethylene crackers and from some of the present chemicals plants in the province also offer feedstock potential for non-commodity chemicals manufacturing in the province.

The continuing development of the Alberta commodity chemicals industry will provide further feedstock potential. The investment picture for chemicals, as it presently stands in the province, is outlined in Table 2.2.

Table 2.2

Petrochemical Projects Under Construction in 1982

Company	Products	Location	Capital Cost	Planned Startup	Annual Capacity
			($ million)		(kilotonne
Esso Chemical	Ammonia, Urea	Redwater	350	1983	616/Ammoni 587/Urea
Sherritt Gordon Mines	Ammonia, Urea	Fort Sask	360*	1983	443/Ammoni 385/Urea
Celanese/Pan. Canadian Petroleum	Methanol	Edmonton	275	1982	700
Alberta Gas Ethylene	Ethylene #2	Joffre	575*	1984	680
Shell Canada Chemical	Benzene	Scotford	350	1983	236
	Styrene	Scotford	400*	1984	300
Union Carbide	Ethylene glycol	Prentiss	330	1984	230
Novacor Chemicals	LLDPE**	Joffre	470*	1984	270
Alberta Gas Chemicals	Methanol III	Medicine Hat	130	1982	400

* includes interest during construction.

** Linear low density polyethylene.

2.4 Manufacturing input costs in the province

All the major chemical plants operating in the province were surveyed during this project to determine the level of chemical plant support infrastructure that is available in Alberta.

The general conclusion was that the availability of labor, energy and support services among others is sufficent for the firms presently operating in Alberta and also for the operation of plants making non-commodity chemicals. The growing petrochemical industry has built up the supply of skilled labor as well as helped to develop the infrastructure for the chemicals manufacturing in the province.

In addition, appreciable support services are available due to other non-chemical industrial activity. Electronic parts and services and also maintenance supplies are obtained from firms serving the energy sector, as are other outside services common to that industry, such as laboratories and maintenance services.

2.4.1 Personnel

The specialty chemical companies find no great problem in attracting employees, even when people were in short supply in the province. At present the supply is good.

Wage rates have been under pressure in the past months although this study did not review the rates in detail. However, 1982 rates for operators were between $10 to $15 per hour. The rate for more junior transient levels has fluctuated greatly. Now it is near the minimum wage of $3.80/hour in the province but it was double that rate two years ago.

Labour rates generally are fairly comparable between Alberta and Ontario among chemical workers. Sarnia area workers have wages about 15% higher than in the Edmonton area at present. Chemical worker wages in the Toronto area are about 17% lower than in the Edmonton area. This may reflect the smaller chemical establishments and more specialty chemical/mixing blending operations in the Toronto area.

Table 2.3

Comparison of Alberta and Ontario Chemical Wages

	Edmonton*	Toronto	Sarnia*
Hourly wages	11.20	9.34	12.85
Alta. advantage (%)	-	(17)	15
Salaried workers	13.13	14.11	14.99
Alta advantage (%)	-	7	14

* based on industrial aggregate

Source: StatsCan 72002 (1983)

Chemists:

Chemists specializing in needed areas are generally "imported" to Alberta, but good general purpose chemists are being turned out by Alberta universities. Recent expansion of the chemicals field in the province also is building the skilled labor pool for chemists. So, acquiring good professional staff does not appear to have been a major problem at any time for firms setting up plants in the province.

Skilled Trades:

Except in the case of maintenance specialists, present non-commodity chemical plants appear to have had little problem in attracting skilled personnel. Their urban location and small staff sizes have attracted people with little difficulty to chemical plants.

In case of maintenance staff, higher wages available elsewhere in the province (including overtime during boom times) has tightened the supply, but the stability of chemical plant operations now offer a large attraction to this type of worker. Supply is reported to be good for experienced machinists, millwrights, etc.

Unskilled:

There is presently a great deal of unskilled labor available now but it was tight during boom periods. Even the unskilled labor tend to have job experience related to construction and pipeline building operations, and this can be a positive factor in hiring.

2.4.2 Utilities

Energy is an input with which Alberta has a major cost advantage compared to other chemical manufacturing locations in North America. Details are given in Table 2.4 on the folowing page.

With regard to electricity, at industrial volumes used by a reasonable sized plant, there is a 38 percent differential between Toronto Hydro and Edmonton Power on rates.

When it comes to natural gas, an Edmonton area plant has a 95 percent cost advantage over a Toronto area plant, and a 66 percent advantage over a plant in Houston, Texas.

Water rates are a mixed comparison. Edmonton rates have a 300 percent disadvantage compared to Toronto, while to Texas there is a 780 percent advantage.

Table 2.4

Energy and water comparisons between Alberta and other locations for chemical plant inputs

	Alberta	Ontario	Texas
Electricity (cents/kWh)	1.55	2.14	n/a
Alberta advantage (%)	-	38	
Natural Gas ($/Gigajoule)	2.44	4.75	4.04
Alberta advantage (%)	-	95	66
Water rates (cents/cu. m)	26	8.6	203
Alberta advantage (%)	-	(300)	780

Natural gas:

Gas does not appear to have the same importance as electricity to non-commodity chemicals plants. However, the Alberta rate is highly competitive with other parts of Canada and even with most of the U.S. chemical "valleys".

Within Alberta natural gas is not regulated, so a volume consumer can negotiate prices with the producers or carriers. Most of the large users in Alberta now have such arrangements.

Water:

Municipal water is available at all the serviced sites in and around Edmonton and Calgary. The water is generally hard except in Edmonton where there is a municipal softening system.

Domestic sewage charges are added to the water bill, and the municipality will usually accept very dilute process wastes without objectionable substances.

2.4.3 Plant regulations

Any chemical plant will need Clear Air and Clean Water permits, first to build and then to operate. The Clean-Water permits are renewed every five years. These acts and the upcoming hazardous waste legislation are handled by the Alberta Environment Department.

Alberta Occupational Health and Safety has rules similar to the U.S. on chemical concentrations in the work place.

Only a major plant that consumes over 1 bcf of natural gas or energy equivalent is required to obtain an industrial development permit. Non-commodity chemical plant investment in the province would not likely require such approvals.

2.4.4 Hazardous waste handling

Federal guidelines are used to regulate aqueous discharges but individual plants may be subject to special controls. Applicants for environment licenses are asked to identify disposition of toxic solid wastes.

Some use of disposal wells has been allowed in the province. There has been minor use of a Celanese well by others (Uniroyal and the Alberta Research Council) as well as one in Calgary. These wells are the only ones taking wastes from other than their owner.

All treatment facilities for hazardous wastes are licensed. Hazardous waste transport also has rigid standards and approvals. Certain wastes now land filled in the province will require handling by an approved treatment facility.

At present the province is developing, at Swan Hills, a $50 million hazardous waste treatment centre. This facility, some 200 km northwest of Edmonton, will come into operation in 1988 and be capable of handling all hazardous wastes, except those that are radioactive.

2.5 Status of Alberta's infrastructure

The Alberta specialty chemicals industry now relies on the support services built up for oil and gas field activities, oil refining, oil sands development and the major chemical plants. Hence, the level of support is larger than expected for just chemical plant activities in the province.

Maintenance:

There are sufficient repair-oriented shops to provide most short term back-up needs. (Edmonton has more strength in this regard than Calgary). Exotic alloy welding may be of occasional concern and experience with glass lined equipment is virtually non-existent.

Spare parts can be a problem for very specialized equipment, but air freight is generally used to avoid excessive time delays. The local stocking level of mill supply houses is reported to be generally good, and most firms are willing to stock to serve chemical plant customers.

Electronics:

While a problem at one time, analytical instrument maintenance is now usually available locally through many of the major instrument vendors. There is usually excellent electronics support available in major centres for most types of repair and regular maintenance.

Reagents and fine chemicals supply:

There is a major chemical warehouse and wholesale industry in Alberta largely related to oilfield and agricultural needs. These companies provide good services acquiring feedstocks, but need to be advised who the supplier is and the specifications of the material needs. They have been more like order takers than sellers in the past. If the demand is large enough they will stock the particular material.

In addition, General Intermediates and Raylo both make certain fine chemicals and have the capability to expand their product lines should local demand warrant.

Containers:

In some container types availability is reported as more limited. For example, glass and plastic jugs have no local production, little competition and prices tend to be high. However, in the case of plastic pails there is local supply and prices are highly competitive.

Other packaging materials such as paper or polyethylene bags suitable for chemicals the supply are available from within Alberta or British Columbia.

2.6 Alberta's technical resources

Research and development:

While much non-commodity chemical development is done in-house the province has a few firms with product development capabilities. For oilfield oriented product development there are a number of good laboratories specializing in formation characteristics.

The Alberta Research Council has excellent chemical testing and development equipment in its Edmonton facilities. In addition to providing custom and contract research, ARC has developed a facilities rental program for firms wishing to do their own R&D but not being able to justify the establishment of their own laboratories.

The growing demand in Alberta by chemical companies for research or product development support gradually is building the expertise of ARC in non-commodity chemicals. The institution has the capability of providing support to this sector, and even establishing expertise in areas such as biology and toxicology that could assist in the development of fine chemicals and products such as pesticides.

With two major universities in the province -- University of Alberta and University of Calgary -- research and product development support can be obtained from the chemical departments of these institutions. In addition, the University of Lethbridge, Athabasca University, the Southern Alberta Institute of Technology (Calgary) and the Northern Alberta Institute of Technology (Edmonton) can all provide assistance and access to potential personnel.

Individual university professors and university facilities are an appreciable help to some companies-- particularly those in the Edmonton area. Oilfield and agriculture chemicals and chemistry are two areas noted by firms surveyed relative to local university/technical school staff strengths.

Laboratory facilities:

Commercial laboratories are oriented towards oil and gas as well as in construction and pollution monitoring testing. These firms provide excellent service and have a normal configuration of testing equipment.

The universities and the ARC have the only laboratories better equipped than the commercial testing laboratories. The University of Alberta appears to provide specialized testing help to chemical companies in the Edmonton area. Also, Raylo can provide a significant capability for many organic testing procedures.

2.7 Comparative costs for capital projects

Perceptions of high capital costs in Alberta due to harsher climates and an over-heated local economy may still exist with the chemical industry. However, capital costs on chemicals plants in the province are close to the North American average. Many of the larger commodity chemicals projects being completed in the province are coming in under budget, and the belief that construction costs are 25% higher than the U.S. Gulf Coast is being dispelled.

Construction costs have declined appreciably in the past few years and virtually any new non-commodity chemicals facility would be built with efficient non-union construction labor. Fabrication skills in Alberta are available for steel and stainless pipe welding. Only the installation of glass lined piping systems require outside labor or contractors.

There are a large number of well qualified vessel and pipe fabrication shops and local shop built modules are possible in all but the most exotic alloys (and glass).

Land, in the past, has been quite expensive in Alberta but prices have softened. Typical costs are:

- 320 acres up - unserviced, suitable for major chemical plant, $2,000-10,000/acre
- 80 acres - minimum without subdivision plans, $5,000-15,000/acre
- 2-10 acres - rural, partly serviced, $10,000 - $20,000+/acre
- suburbs industrial park, serviced, $20,000-45,000+/acre

On a comparative basis Alberta stacks up quite well against Ontario locations such as Sarnia and Houston, Texas, for example. For unserviced land suitable for a larger plant Alberta likely has a 25 percent advantage over Texas and a 50 percent advantage over Ontario. On serviced land Alberta's advantage over Sarnia ranges from equivalent to 40 percent. Details are given in Table 2.5.

Table 2.5

Comparative Land Costs for Chemical Plants

	Alberta	Ontario	Texas
Raw land (Cdn $/acre)	5-15,000	25-75,000	13-40,000
Serviced land (Cdn $/acre)	20-75,000	75-85,000	n/a

2.8 Transportation factors

Rail transportation is an important cost element for just about any chemical product made in Alberta, the local market normally constituting only a small portion of total disposition of a plant's output. Published freight tariffs exist for several bulk chemicals currently being manufactured amd shipped from Alberta. However, it is difficult to predict what will be the rate applying to any new product made in the province.

Freight rates are established on the basis of such things as product value, hazard rating, total annual volume and a variety of other considerations in addition to the rail distance between source and destination. Any quoted rate would, of course, not include any handling charges within a port area if one was seeking to establish a transportation cost on offshore shipments. The terminal charges would include switching of rail cars and unloading are generally negotiable.

Published rates for constant movement of product, usually commodity chemicals, provide an indication of the freight rate levels being used today for shipping chemicals out of the province. Examples of freight rates are given in Table 2.6 on the next page.

Table 2.6

Examples of Agreed Freight Rates

Cellulose acetate from Clover Bar to Drummondville, Que:

Rate: $3.05/cwt (in 50-ft cars with minimum 90,000 lb) to $3.25 (40-ft cars, minimum 60,000 lb).

Vinyl chloride from Fort Saskatchewan to Port Robinson, Ont:

Rate: $64.68 per 2,000 lb (i.e. $ 3.23/cwt) in tank cars minimum 180,000 lb.

Crude tall oil from Hinton, Alta to Toronto:

Rate: $4.76/cwt in jumbo tankcars (minimum 158,00 lb)

Tall oil from Hinton, Alta to New Westminister, B.C.:

Rate: $2.78/cwt (150,000 lb minimum) and shipping on to Portland, Ore adds an additional U.S. $1.37/cwt charge.

Acetic anhydride or acetic acid from Clover Bar to Collingwood, Ont:

Rate: $ 4.89/cwt in tankcars (80,000 lb min.)

Here are some known charges for products going from the CN Saskatchewan crossing point (Northgate, Sask.) to Chicago (the Canadian portion of the movement must be added to get the combination rate):

	(US$/cwt)
Tall oil fatty acids	
Small tank car, min 60,000 lb	4.48
Tankcar, min 150,000 lb	3.17
Chemicals not otherwise indicated by name (NOIBN) (products whose value does not exceed 50 cents/lb)	
Tankcars,no minimum,98% shell capacity	5.95
Cars, min 40,000 lb	4.94
Cars, min 60,000 lb	4.31
Cars, min 80,000 lb	3.99

Through rates vary according to destination. For comparison purposes we note the following:

	(US$/cwt)
Vinyl chloride:	
Ft. Sask to Los Angeles, t/c, min 180,000	4.07
Ft. Sask to Illiopolis, IL, t/c, min 175,000	3.40
Vinyl acetate:	
Clover Bar to LA , t/c, min 180,000 lb	4.21

SECTION III

SELECTED NON-COMMODITY CHEMICALS

Of the thousands of chemicals sold commercially, most of which are imported by Canadian industry (See Appendix II), only a selected number deserved serious consideration as capable of being manufactured in Alberta. The list involved some 107 chemicals and were evaluated using further information and analysis.

The chemicals have been selected because of:

- previous interest by chemicals firms in manufacturing the product in Alberta or Canada,
- a favorable raw material position in Alberta or western Canada,
- growth potential of the chemical,
- the likelihood of new investment because of market focus and/or impending technological change.

The selected chemicals can be grouped in accordance with a recognizable end-use function or a common raw material base. Section 3.1 reviews the appropriate rationales for assessing the different groupings. There follows a more detailed examination of the chemicals. Included in this examination is the siting of some of the companies both in Canada and abroad that are involved in the various markets under discussion. Their inclusion ought to provide a better appreciation of the competitive forces at work.

3.1.0 The manufacture of pesticides

The western plains of North America constitute a substantial market for herbicides and other pest-control agents. Pesticides are by and large specialty chemicals of high value added synthesized from several of the common petrochemical building blocks. The technology, both in terms of process and the nature of the biologically active ingredient, changes rather quickly and those changes often require the extensive use of experimental stations close at hand. As noted in an earlier departmental study (Sabourin, 1977), the Canadian industry "is primarily formulators (with the exception of the phenoxies), importing a large portion (95 percent) of the active ingredients...(and) approximately one-half of the formulated products are also imported."

Herbicides represent one of few markets where consumption patterns point to substantial growth in demand. The Canadian herbicide market alone runs at $500 million annually and the cereals crop consumption of products is almost $300 million of that figure, making the market sufficiently large to justify manufacturing.

3.1.1 Manufacture of chemicals for industrial explosives

The primacy of the resource industries in the western portion of North America is likely to be maintained for decades to come, unless there are unanticipated population shifts. Explosives are already widely used for coal and metal mining, oilwell shooting and construction in both western Canada and the U.S. states west of the Mississippi. The fact that the manufacture of most explosives are based on natural gas (via ammonia and nitric acid) happily coincides with the direction the market is taking.

3.1.2 Manufacture of industrial surfactants

With ethylene oxide currently being manufactured in Alberta, sulfur (for sulfonation reactions) indigenous to the province and the prospect of several hydrophobes (alpha-olefins, fatty acids, etc.) being manufactured locally, the option of making surface-active agents for detergent and other purposes (wood pulping, petroleum demulsification, etc.) is becoming more attractive. If and when enhanced oil recovery creates a demand for petroleum sulfonates or other surfactants, regional markets for these surfactants will be broadened significantly.

3.1.3 Manufacture of other oilfield and mining specialties

Several products derived from tall oil, ethylene diamine, acrylates, vinyl acetate and cellulose are also related to the resource industries. Alberta oilfield specialties (including drilling muds and corrosion inhibitors) are formulated in the main from imported ingredients, including water-soluble polymers.

3.1.4 Manufacture of engineering and like polymers

The promise of even larger motor-vehicle, telecommunications and business-machine fabricating industries in California and in the Pacific-Rim countries also suggests much increased demand for the so-called engineering resins. Although Alberta has no sophisticated plastics processing industry to speak of, it could provide some of the resins to processors in these other regions -- especially if they contain styrene, a monomer now available in Alberta.

3.1.5 Manufacture of chemicals derived from waste streams

Large-scale chemical processing often results in the creation of waste streams that can be regarded either as a nuisance (they must be buried or otherwise inactivated) or as a source of valuable chemicals. Kraft pulp mills must export recovered tall oil and/or turpentine to the United States. The ethane crackers at Joffre have side streams that are currently burned as fuel or shipped unseparated to distant customers.

The refining of sugar beets yields a molasses that could be used for fermentation products (citric acid, etc.). An acetic acid plant generates formic acid, which at present must be discarded but could be used for amine derivatives or sodium hydrosulfite.

3.1.6 Manufacture of chemicals derived from sulfur

Several sulfur products are currently being produced in Alberta and perhaps more of the same could be manufactured profitably. Other derivatives such as mercaptans and sulfites may also fit into the Alberta environment. The proximity of adequate markets is a critical factor since sulfur is readily available in many other manufacturing areas.

3.1.7 Manufacture of chemicals derived from potash

The world's largest reserves of potash are in Saskatchewan next door to Alberta. Some of that potash could be upgraded to potassium chemicals. Caustic potash manufacture would be an initial move in this direction and may be warranted at an early date. Low energy costs (both power and steam) are required and there must be an outlet for coproduct chlorine (which a developing chemical industry and/or the regional kraft pulp mills should offer).

3.2.0 Selective herbicides

Canada has been a major market for herbicides. An estimated $500 million is spent annually for weed control with a major portion of the expenditures for western Canada's cereal crops. Despite the impressive dollar numbers, none of the active ingredients for these herbicides is produced in the country. The plants making 2,4-D and MCPA amines and esters for non-selective broad-leaf control have been shut down during the past couple of years. All of the more complex organic compounds employed in the selective pre-emergent and post-emergent type products have always been imported.

3.2.1 The manufactured products

The major herbicides of interest from a market point of view are:

Atrazine (2-chloro-4-ethylamino-i-isopropylamine-s-triazine) is produced from hydrogen cyanide and chlorine (to produce cyanuric chloride), ethylamine, isopropylamine and caustic soda.

One of the group of triazine herbicides, Atrazaine has become popular as a herbicide on corn and sorghum. These plants are resistant to the product, since their enzymes break down the chemical.

Atrazine dominates the corn market in the U.S. being used in some 50 percent of total acres grown. In Canada, atrazine is used on some 65 percent of the acres of corn grown.

Bromoxynil (3,5-dibromo,4-hydroxybenzonitrile) is derived from p-hydroxybenzaldehyde, bromine and caustic soda. (Hydroxybenzonitrile is an alternative starting material.)

Bromoxynil kills broadleaf varieties of weeds such as wild buckwheat, smartweed, lamb's quarters and wild mustard. Mixed with MCPA it is further effective against a larger range of broadleaf weeds. Several products on the Canadian herbicide market use bromoxynil either alone or in combination with other herbicides.

Diallate and **triallate** are thiocarbamates obtained from the reaction of carbonyl sulfide, diisopropylamine and a chlorinated propylene.

Avadex BW, a diallate, is a preemergence incorporated herbicide used to control wild oats in wheat, barley, flax and some cash crops such as sugar beets and peas. Its major use in Canada is on wheat and barley.

Dicamba is based on 3,6-dichlorosalicylic acid and requires the chlorination of benzene and the conversion of the trichlorobenzene to the corresponding phenol.

Dicamba or "Banvel" is a benzoic acid herbicide used to control pigweed, lamb's quarters, buckwheat and thistle in barley, oats, corn and wheat.

Difenzoquat is a quaternary compound (1,2-dimethyl-3,5-diphenyl-1H-pyrazolium methyl sulfate) involving the reactions of acetophenone, benzaldehyde, hydrazine hydrate, trimethylamine and ethylene dichloride.

Sold under the trade name "Avenge", difenzoquat is a liquid herbicide for control of wild oats in wheat and barley. "Avenge" has found good acceptance in the North American cereals market, with the Canadian use of the product likely the largest in the world.

Trifluralin is a,a,a-trifluoro-2,6-dinitro-N,N-dipropyl-p-toluidine and is a nine-step process that involves p-chlorotoluene, hydrogen fluoride, a nitric/sulfuric acid oxidizing agent and di-n-propylamine.

Trifluralin, or "Treflan" the Elanco brand name, is used to control both grassy and broadleaf weeds in cereals and rapeseed. It is one of the major products used in Canadian agriculture to control weeds.

In the U.S., "Treflan" has as its major market soybeans and cotton, followed by wheat and rapeseed.

While the economic size of plant varies widely with the number of steps required to make each herbicide, a minimum size plant must make 1000 to 1,500 tonne of active ingredient. Capital costs run $30 to $60 million for a plant on a greenfields site including waste disposal. Disposal facility capital costs can run to 30 to 40 percent of total capital costs on these plants.

PESTICIDES AND THEIR PRECURSORS

Base chemicals	First-step intermediates
[Methanol]*+[Ammonia]*->	[Methylamines]
[Ethanol]+[Ammonia]*-->	[Ethylamines]
[Isopropanol]+[Ammonia]->	[Isopropylamines]
[n-Propanol]+[Ammonia]->	[n-Propylamines]
[CO]* + [Chlorine]*-->	[Phosgene]
[Benzene]*+[Chlorine]*->	[Trichlorobenzene]
[Toluene]+[Chlorine]*-->	[p-Chlorotoluene]
[Toluene]------->	[Benzaldehyde]
[Methane]*+[Ammonia]*---->	[Hydrogen cyanide (HCN)]
[HCN] + [Chlorine]*-->	[Cyanuric chloride]

---

* already manufactured in Alberta

PESTICIDES AND THEIR PRECURSORS

Intermediates   Pesticide active-ingredient

[Monomethylamine]-->[Methyl isocyanate]--->[Carbamate insecticides]

[Trimethylamine]+[Benzaldehyde]--> [Difenzoquat]

[Ethylamine]+[Cyanuric chloride]-> [Atrazine]

[Diisopropanolamine]----> [Diallate,triallate]

[Di-n-propylamine]------>
[Trifluralin]
[p-Chlorotoluene]------->

[Trichlorobenzene]------> [Dicamba]

[p-hydroxybenzaldehyde]--> [Bromoxynil]

* already manufactured in Alberta

3.2.2 Alberta's strengths

Selective herbicides to control weeds on cereal crops continue to be a growth market in Canada even when agriculture generally is suffering. The U.S. midwestern states are also large consumers of these herbicides.

Alberta is part of a regional market that runs to almost $300 million per year and has herbicides with volumes of consumption that run in the 1 to 4 kilotonne level. Such product volumes allow for entry of manufacturing providing product registration can be obtained.

Most of these complex organic compounds are built on basic chemicals (chlorine, ammonia, sulfuric acid, nitric acid, benzene, caustic soda and methanol) already manufactured in Alberta.

Alkyl amines, methyl isocyanate, mercaptans, toluene, benzaldehyde, cyanuric chloride, p-chlorotoluene and certain other intermediates could be produced in the province if the circumstances are right.

Waste disposal, a chronic problem with most organic synthesis of this kind, could be more readily tackled in the more sparsely populated prairies than in many other rather congested manufacturing centers.

3.2.3 Supply/demand balance

The total Canadian herbicide market runs to $500 million a year at the farm level. In western Canada in 1982 herbicide usage was some $270 million at the farm level. More than half of the product was used on wheat and 20 percent on barley. Growth rates have been on a dollar basis running at 15 percent over the past few years in western Canada, with real market penetration about 3 to 5 percent.

The Canadian market for cereals herbicides is a major one, despite the fact that the U.S. market outweighs total Canadian herbicides sales by five to one. Also, some of the herbicides used on the dryland of the Canadian prairies have greater use in this country than in the United States. This market size in herbicides use gives Alberta a stronger position vis-a-vis the manufacture of the active ingredients.

The value added in the distribution of herbicides in Canada is substantial. Products coming into Canada have their value raised by 160 to 350 percent before going to the farm level. This likely is both good and bad for herbicide manufacturing. For a potential manufacturer it means the distribution value added can to some extent be used to justify his investment.

Table 3.1

Imports of herbicides and active ingredients, 1982

	kilotonne	($ '000)
Bromoxynil herbicides	0.4	2,340
Trifluralin herbicides	0.25	1,234
Triallate	3.13	26,115
Atrazine	0.74	2,440
Nitrile formulations (bromoxynil)	0.98	8,530
Toluidine isomer derivatives (trifluralin)	2.95	25,068
Difenzoquat (Avenge)	0.6	14,784
Dicamba	1.22	10,095

The negative factor is that without much direct competition the justification of manufacturing in Canada is low when you can make good margins simply distributing the chemicals from a parent company plant without the hassle of production. Unless a firm needs production capacity for its herbicide on a global basis, there is little financial incentive to make the product in Canada.

Table 3.1 shows the value at import of the active ingredients and indicates the substantial volumes that exist to support a herbicide plant.

For the more generic products the supply to the Canadian market is substantial. Atrazine, bromoxynil and trifluralin are herbicides that are made in either the U.S. and Europe along with other countries such as Israel and Argentina.

Patented and branded products such as Avadex and Banvel tend to be made in a single plant by the patent holder.

3.2.4 Major suppliers

CIBA-GEIGY has the dominant market position in atrazine.

Cyanamid Canada has been very successful with its difenzoquat in Western Canada. The difenzoquat is currently being imported from the Netherlands but at some point in time Cyanamid will undoubtedly invest in new facilities in North America.

Eli Lilly's Elanco division, which has had patent control over trifluralin, supplies most North American formulators. The company has a compounding facility outside of Edmonton but does its manufacturing in the United States.

Hoechst Canada has a formulating plant in Regina that compounds products based on the diclofop-methyl it imports from its West German parent.

May & Baker and parent Rhone-Poulenc manufacture bromoxynil in the United Kingdom and France. Canada constitutes a major market for bromoxynil.

Monsanto relies on both Avadex (diallate) and Roundup (glyphosate) for much of its gross income and earnings. The Avadex line in particular has been the top pre-emergent product for wild oats control.

Shell Canada has access to the ag-chem technology of the Shell International organization (Shell Chemical makes atrazine in the U.S.) though the company sold its ag-chem formulating business to CIBA-GEIGY in 1982.

Stauffer Chemical is especially strong in thiocarbamate herbicides (Sutan +), fungicides (Captan) and insecticides (Dyfonate) with emphasis on corn and soybean applications.

Uniroyal has begun to market a trifluralin in competition with Elanco. Currently the active ingredient is being imported from overseas. Uniroyal made 2,4-D and MCPA at Clover Bar until recently and still owns the facility there.

Velsicol Chemical sells dicamba as a broadleaf weed and brush control agent in wheat, barley and corn areas. (The company also markets Carbyne for wild oats control in Western Canada.)

3.3.0 Alkylamines and derivatives

The alkylamines are of strategic importance because they are the intermediates for a range of specialized chemicals that could fit into the Alberta manufacturing environment. The methylamines are stepping stones to a number of herbicides, choline chloride (a vitamin supplement for animal feeds), water-gel explosives and dimethyl formamide. Higher alkylamines are tied to herbicides to an even greater extent.

3.3.1 The manufactured products

Alcohols are reacted with ammonia in either the liquid phase or at elevated temperatures (400 C.) and pressures in the vapor phase. The substitution of the hydrogen atoms attached to the nitrogen with alkyl groups is random but production of one of the different amines can be minimized by recycling the others to the reactor feed.

The methylamines and diethylamine are gases at ambient temperatures. Therefore, they are sold in aqueous solutions as well as in the anhydrous form (using pressurized containers). The higher alkylamines are liquids.

Monomethylamine, which can be reacted with phosgene (chlorine + carbon monoxide) to produce **methyl isocyanate**, is the key component for a host of carbamate insecticides. The monomethylamine is also the starting point for a proprietary water-gel explosive.

Dimethylamine's major outlet is as **dimethyl formamide** but it can also be reacted with phosgene to make **dimethyl carbamoyl chloride** as intermediate for a couple of other carbamate insecticides. DMA has been used extensively to convert 2,4-D acid and MCPA to the amide form from application as herbicides. The amide is also an intermediate in the manufacture of certain selective herbicides.

N,N-dimethylformamide (DMF) is the reaction product of methyl formate with dimethylamine. It is therefore a derivative of methane-based petrochemicals (primarily ammonia and methanol) and extremely sensitive to the costs of these petrochemicals. DMF, a non-corrosive liquid miscible with water and most organic solvents, excels as a solvent. It is sold in tankcar and drum quantities.

A source of sodium formate (usually neutralized formic acid) is methylated and then reacted with dimethylamine to yield the DMF. Methyl formate can be obtained directly from methanol, which would be reacted with carbon monoxide.

Trimethylamine could be converted to **choline chloride** on site or shipped to an existing choline chloride producer in the U.S. or elsewhere. Difenzoquat production would involve some use of the trimethylamine.

Choline chloride, a gastrointestinal agent, is already produced in Canada but the domestic market (especially that in the western provinces) is also served by imports.

A colorless viscous liquid with a strong amine odor, beta-hydroxyethyltrimethylammonium hydroxide (Vitamin B4) occurs in egg yolk, animal organs, seeds, vegetables and legumes. It is essential to the diet of certain animals and in man, is required for lecithin formation and can replace methionine in the diet. This choline base is, however, normally sold as its chloride, which is synthesized as white crystals. Choline dihydrogen citrate and choline bitartrate are optional forms.

Trimethylamine is usually reacted with ethylene oxide and hydrogen chloride (ethylene chlorohydrin is an alternative) in a reactor. Drying equipment is optional since choline chloride can be used in either liquid or solid form.

Ethylamine and the various **propylamines** are involved in several of the key synthesis leading to the more popular selective herbicides.

```
[Ammonia]-------
               |
[Methanol]---------->[Monomethylamine]
               |         |
               |         ----------->[Phosgene]
               |                         |
               |               [Methyl isocyanate]--
               |                                   |
               |                [Carbamate insecticides]
               |
               | ---->[Dimethylamine]---><--[Methylformate]
               |                         |
               |              [Dimethylformamide]
               |
               |           -------------><--------[Phosgene]
               |                         |
               |           [Dimethyl carbamoyl chloride]
               |
               |-->[Trimethylamine]--><----[Ethylene oxide]
                          |           |
                          |            <--[Hydrogenchloride]
                          |
                          |    [Choline chloride]
                          |
                          |------------><----[Benzaldehyde]
                                        |
                                        | <----[Acetophenone]
                                        |
                                        | <-------[Hydrazine]
                                        |
                        [Difenzoquat]<-

                               <----------[Dimethyl sulfate]

                               <--------[Ethylenedichloride]

[Ethanol]----------->[Ethylamine]----><--[Cyanuric chloride]
                                      |
                                  [Atrazine]
                                        |
[Isopropanol]------->[Isopropylamine]-->

                 ---->[Diisopropylamine]--><--[Carbonyl
                                           |      sulfide]
                                           |<--[Chlorinated
                                           |      propylene]
                          [Diallate,triallate]

[n-Propanol]-------->[Dipropylamine]------><--[Nitric acid]
                                           |
                                           |<--[p-Chloro
                                           |         toluene]
                                           |
                                           |<-----------[HF]
                          [Trifluralin]<----
```

3.3.2 Alberta's strengths

The cost of natural gas is decisive to the economics of making ammonia and methanol, the two feedstocks for methylamines manufacture. Alberta has a multiplicity of world-scale ammonia and methanol plants.

Sodium formate is a byproduct of the manufacture of pentaerythritol at Clover Bar and is being discarded at present. It is therefore a possible source of methyl formate, the other major precursor to dimethyl formamide.

Choline chloride manufacture, entailing the reaction of the TMA with ethylene oxide and hydrochloric acid, can be carried out at relatively low cost because ethylene oxide and the acid are already produced on a large scale in the province.

A substantial tonnage of choline chloride is consumed in animal feed blending operations in the U.S. western states as well as on the Canadian prairies. The only choline chloride producers basic in methylamines are in Indiana (IMC) and in Sarnia.

There may be the prerequisites in Alberta for the manufacture of herbicides and/or explosives, in which event the local demand for various alkylamines would be greatly enhanced.

Though methylamine plants seemingly can operate profitably at rates as low as 5,000 tonne per annum, scale is an obvious advantage. Plants located in West Virginia and in Florida have capacities in the 45 to 70 kt/year range.

A multi-purpose facility -- i.e. one that could handle the manufacture of the higher amines as well as of the methyl types -- may not be justified unless there is some assurance that the appropriate alcohols are available at attractive prices or that outlets for these amines are on the horizon. Neither ethanol nor isopropyl alcohol are currently produced in Alberta although there is enough ethylene and propylene to support their manufacture.

3.3.3 Supply/demand balance

North American consumption of alkylamines in 1982 was not much more than 70 percent of that in 1979. The recession and reduced plantings in the agricultural sector ended an era of unprecedented market growth. Exports of amine-based pesticides have also declined as new production units emerged offshore and Third World countries curtailed hard-currency purchases of industrial goods and agricultural chemicals. The PIK program in the U.S. made 1983 an equally poor year for the amine suppliers but demand should come back to earlier levels in the next few years.

Consumption of dimethyl formamide in the United States has been estimated at 40 to 45 kt/year although no accurate measure is available. (Du Pont has a large captive use for DMF in its Orlon operations south of the border.) DMF usage is expected to increase at a rate of 3 percent per annum. In other words, solvent applications for DMF appear to have been fully explored and the product can be regarded as relatively mature. The concentration of North American polyacrylonitrile fiber production in the southeastern U.S. gives the two American producers a logistical edge over any Canadian vendor.

Choline chloride usage west of Windsor is relatively small because the prairie provinces do not have nearly the same animal population as have Ontario and Quebec. Consumption west of Ontario is probably below 1,200 or 1,300 tonne per annum. There is a greater western bias to the U.S. market. Ralston Purina, the St. Louis firm, requires about a large tonnage per year. American production of choline chloride was reported as being 20.7 kt in 1971, 23 kt in 1978 and 28.8 kt in 1980. Total consumption of choline chloride in the U.S. will probably be close to 32,000 tonne per annum in 1984.

The agricultural sector of the North American economy suffered severely during the 1982-83 period but the increasing sophistication of the farmer promises a growing demand for nutritional products such as choline chloride.

3.3.4 Major suppliers

Air Products & Chemicals manufactures methylamines in Pensacola, Florida.

Bayer excels in isocyanate chemistry and is a European producer of insecticides based on methyl isocyanate.

Celanese Chemical has access to the amines technology of affiliate Virginia Chemicals (which makes amines at Portsmouth, Va) and also has methanol and methyl formate available at its Clover Bar plant in Alberta.

Chinook Chemical is the Ontario producer of methylamine, dimethyl formamide and choline chloride.

Dow Chemical is a choline chloride producer in the U.S. and has both ethylene oxide and hydrochloride acid at hand in its Fort Saskatchewan works.

Du Pont Canada was Canada's largest consumer of methylamines (the mono for explosives made in North Bay and DMF for an Orlon plant in Maitland, Ont.) but has since ceased making Orlon. E.I. du Pont, which makes methylamines at Belle, WVa and LaPorte, TX, has a large captive demand for DMF.

IMC Chemicals operates a small methylamines plant at Terre Haute, Indiana and is also a choline chloride producer.

Syntex Agribusiness Inc of Springfield, Mo is a manufacturer of choline chloride.

Thompson-Hayward Chemical is a Kansas City producer of choline chloride.

Union Carbide is a consumer of monomethylamine (converted to methyl isocyanate) in the U.S. as manufacturer of the Sevin insecticide.

3.4.0 Halogenated intermediates

Manufacture of many organic specialties entail the use of chlorinated or brominated intermediates. These intermediates can in some cases be brought into the province to support specific synthesis. The economics of such operations, however, would certainly be improved if the intermediates were available locally.

3.4.1 The manufactured products

Methyl chloride is a reagent widely used for transforming fatty amines into quaternary ammonium compounds. It is also an intermediate in the manufacture of paraquat herbicide and of methyl cellulose. The volume uses of methyl chloride, however, are in the production of silicones and tetramethyl lead. The producers of these latter derivatives tend to rely on captive methyl chloride.

This colorless, non-corrosive, liquifiable gas is one of the most basic organic chemicals. It is widely distributed though flammable and a moderate explosive hazard.

The chlorination of methane in the presence of light or a catalyst can be controlled to yield mostly methyl chloride, methylene chloride or chloroform -- though in most instances a substantial tonnage of each of these chlorinated products is manufactured on a continuous basis.

Chlorobenzenes, generated by chlorinating benzene, would probably be upgraded on site. The monochlorobenzene has application as the precursor for **phenol** -- assuming a cumene peroxidation or toluene oxidation unit is not feasible for Alberta's particular conditions -- and **nitrochlorobenzenes.** The o-dichlorobenzene is a pesticide intermediate (as is trichlorobenzene, which can be taken to the popular Banvel herbicide). Whatever p-dichlorobenzene that is produced, would almost necessarily be sold as a moth repellent and space odorant.

Monochlorobenzene and the o-dichlorobenzene are colorless, volatile liquids whereas the para isomer is normally recovered as white crystals.

The manufacture of the chlorobenzene is relatively simple but does involve the simultaneous production of the mono and di-substituted hydrocarbons.

Dry benzene and catalyst (iron turnings) are charged into a chlorinator on a batch or continuous basis. If the primary demand is for the monochlorobenzene, the chlorinator can also function as a fractionator. The partially chlorinated material runs into a distillation unit where the benzene is distilled, condensed and returned to the chlorinator. The monochlorobenzene is withdrawn from the fractionating column and neutralized and distilled.

Chlorotoluenes are also intermediates for pesticide manufacture. The m-chlorotoluene, for example, is a precursor for Modown herbicide and 2,5-dichlorotoluene ends up as Amiben. The starting material for trifluralin is p-chlorotoluene.

The herbicide Tordon could be synthesized if **2,3,4,5-tetrachloro-6-trichloromethylpyridine** were available via the chlorination of alpha-picoline.

Chloroacetic acid has previously been manufactured in Alberta (as a stage in the production of 2,4-D and MCPA herbicides) and is a necessary first step in any output of carboxymethyl cellulose or other cellulose ethers.

Cyanuric chloride, derived from hydrogen cyanide and chlorine, is an intermediate for the manufacture of several herbicides (Capaprol, Pramitol, Sancap, simazine, Igran, Bladex, Outfox, Sumitol, Cycle and Evik).

Phosgene, also known as carbon oxychloride or carbonyl chloride, is the chlorine product intermediate to the isocyanates used in pesticide manufacture. It is not normally a merchant product because it is so hazardous to transport, but there is no technical obstacle to making phosgene on site if the chlorine and carbon monoxide precursors are at hand.

Phosgene is made by the reaction of CO and chlorine in the presence of a catalyst (usually activated carbon granules). The two feed streams are separately dried, filtered and then metered and mixed and and fed into a reactor. The reaction is highly exothermic so that the not product gases must be put through a condenser where liquid phosgene is recovered. Solvent scrubbing is also part of the process.

Phosgene is a necessary first step in the manufacture of **methyl isocyanate**, the key to the production of the **carbamate insecticides.** It is also involved in the manufacture of a number of products **ethyl chlorothioformate** (for Ordram, Ro-Neet, Eptam and Sutan+ herbicides); **n-propyl chlorothiolformate** (Vernam, Tillam herbicide); **p-chlorobenzyl chlorothiolformate** (benthiocarb herbicide); **phenyl isocyanate** (for Tupersan and propham); **m-chlorophenylisocyanate** (Carbyne, Furloe), **dimethyl carbamyl chloride** (Tandex); **methyl chloroformate** (Betanal, Asulox); **ethyl chloroformate** (Betanex); **3,4-dichlorophenylisocyanate** (neburon, Lorox, diuron); **p-chlorophenylisocyanate** (Telvar); **3-chloro-4-bromophenylisocyanate** (Maloran) and **p-chloro-phenoxyphenyl isocyanate** (Tenoran).

Chlorine, caustic soda and ammonia are raw materials for the manufacture of **hydrazine**, which can be used as a pesticide intermediate, an oxidizer in explosives, a rocket fuel, a blowing agent and an oxygen scavenger in boiler water.

The classic route to hydrazine is via the Raschig process, which involves the reaction of a solution of sodium hypochlorite with an excess of ammonia. In a related "Ketazine" process the caustic and chlorine are not first converted to sodium hypochlorite but used directly to react with the ammonia in an acetone medium. A new French plant employs hydrogen peroxide as the oxidizing agent instead of the sodium hypo. The process involving the interaction of ammonia, methyl ethyl ketone and H2O2 reportedly gives a higher yield, uses less energy and has no byproduct sodium chloride to dispose of. (The MEK is recycled.) The conventional Raschig process, on the other hand, has no organic residues.

OTHER CHLORINATED SPECIALTY PRODUCTS

Base chemicals First-step intermediates

[Chlorine]*+[Methanol]*-----------> [Methyl chloride]

[Chlorine]*+[Carbon monoxide]*-----> [Phosgene]

[Chlorine]*+[Hydrogen cyanide]----> [Cyanuric chloride]

[Chlorine]*+[Caustic soda]*-----> [Sodium hypochlorite]

Intermediates Specialty products

[Methyl chloride]+[Fatty amines]-> [Quaternaries]

[Methyl chloride]+[Silicon]------> [Silicone resins]

[Sodium hypochlorite]+[Ammonia]--> [Hydrazine hydrate]

[Phosgene]+[Monomethylamine]-----> [Methyl isocyanate]

[Benzaldehyde]+[Chlorine]*-------> [Benzyl chloride]

[Benzyl chloride]----------------> [Benzyl alcohol]

[alpha-Picoline]+[Chlorine]*----> [Chlorinated
a-picoline (Tordon)]

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* already manufactured in Alberta

3.4.2 Alberta's strengths

A world-scale chloralkali facility functions in Alberta. It has the advantages of processing on-site brine and having relatively low energy costs. (Natural gas is the fuel used to generate both the power and steam requirements.)

Any production of caustic potash would generate additional chlorine. (See Section 3.16.)

Several of the other raw materials -- synthesis gas for phosgene, hydrogen cyanide for cyanuric chloride, benzene for chlorobenzenes, methanol for methyl chloride, acetic acid for chloroacetic acid and toluene for chlorotoluenes -- are either produced in the province or could be made available. For example, the C5+ stream from the Alberta Gas Ethylene crackers is almost half benzene and part of the feed for the Scotford benzene plant is a toluene/xylenes stream that is to be dealkylated for want of better options.

Chlorine costs are very sensitive to the price of electric power and of fuel gas (in part for the recovery of the caustic coproduct). Alberta's favorable energy position vis-a-vis the American Gulf Coast should be enhanced as power rates rise in the southern states and deregulation of the natural gas industry comes into effect.

The closest facilities engaged in similar types of chlorinations are often on the U.S. Gulf Coast. Presumably markets within easier reach of an Alberta location would be open to the Canadian producer.

Waste disposal is an ever pressing problem for operators of plants manufacturing chlorinated products in rather heavily-populated areas. If Alberta producers are able to take advantage of the prairie terrain and more modern waste disposal technology, they will be less burdened with regulatory conditions.

Hydrazine manufacture requires not only low-cost chlorine and caustic (for the production of sodium hypochlorite, the oxidizing agent) but also a source of ammonia and a supply of steam (for dehydration purposes). Alberta is blessed with below-average costs for all of the materials employed in this "Raschig" process.

3.4.3 Supply/demand balance

Altogether there is about 55 kt/year of hydrazine capacity around the world chasing a global market of perhaps 38 to 40 kt/year. During the period from 1973-74 hydrazine shortages, selling prices of imports climbed as high as $4/lb in the United States. Mobay responded with a new plant in Texas but since then 1979 there has been substantial overcapacity and a levelling off in demand. Stagnation in the agricultural business and reduced purchases by the American military has had a depressing effect on production and prices. Imports from France and/or Japan have added to the woes of the North American producers.

On the assumption that the urethane market in North America will expand at an annual rate of close to 5 percent, phosgene consumption on this continent should be in the neighborhood of 800 tonnes a year by 1987. However, there being no merchant market for phosgene, the overall supply/demand balance is irrelevant. North American methyl isocyanate production, based in the southeastern U.S.A., has been limited by the 1982-83 downturn in pesticide usage.

Consumption in Canada of methyl chloride has averaged between 3 and 4 kt/year in the past 10 to 12 years. No silicone resins are made in Canada nor is tetramethyl lead a popular component in gasoline antiknock compositions in this country. Therefore almost half of the the imported methyl chloride is purchased by Polysar for butyl rubber manufacture. Dow is the second largest consumer of methyl chloride (for Styrofoam production at three separate locations).

Close to 200 kt of methyl chloride are consumed annually in the United States for silicone resin manufacture. Usage of methyl chloride by Ethyl, Du Pont, and others is gradually declining and may be no more than 13 kt/year by 1985.

There is excess capacity in the U.S. resulting from the recession and a decline in tetramethyl lead demand following the new regulations limiting the leading of motor gasoline. More relevant is the promise of increasing demand for silicones. A annual growth rate of 6.5 percent is projected for this industry which means that by 1985 consumption of methyl chloride for silicones alone could reach 230 to 235 kt/year.

The largest outlet for monochlorobenzene in North America is now the isocyanates industry. The MCB is the preferred solvent carrier in the manufacture of both TDI and MDI. About 50 kt are consumed annually in these plants. Another 40 to 45 kt are required per year for the production of chloronitrobenzenes, intermediates in the manufacture of dyestuffs in the United States. Another important end-use for the MCB is diphenyl oxide. (Dowtherm, for example, is butylated chlorodiphenyl oxide.) DDT manufacture was once very important to the vendors of MCB but currently no more than 6 or 7 kt/year of the mono goes into DDT production. Indeed, twice as much MCB ends up in other pesticides (Lasso, Prowl formulations).

About a third of the para-dichlorobenzene produced in the U.S.A. is sold as room deodorant. Another 6 kt of PDCB is used annually for moth control and a substantial tonnage (3 to 4 kt/year) goes to Phillips' Borger, TX plant for the production of polyphenylsulfide (PPS) resins. The U.S. vendors of para rely on the export market to move a relatively large portion of their output.

The ortho isomer is employed mainly as the precursor for 3,4-dichloroaniline, which is an intermediate for both dyes and for biologically active compounds. (Probably 15 kt/year of ODCB ends up in the chlorinated aniline.) Additional ortho-dichlorobenzene is sold as an alternative solvent in TDI manufacture or for other solvent applications. A modicum of ortho is used directly in the manufacture of dyes and pesticides.

The matching of supply and demand in the chlorobenzenes is complicated by the need to dispose of various coproducts.

3.4.4 Major suppliers

Allied Chemical Canada has access to its parent's knowhow for the manufacture of methyl chloride and chlorobenzenes.

Bayer is a large-scale manufacturer of phosgene (for its widespread isocyanates business) in several global locations. It manufactures methyl isocyanate in Europe. Bayer's U.S. subsidiary, Mobay Chemical, manufactures hydrazine in Baytown, NJ, a portion of which goes to Kansas City for conversion to Sencor, a thiodiazole herbicide.

Diamond Shamrock chlorinates methanol in Belle, WVa to produce methyl chloride, methylene dichloride and chloroform.

Dow Chemical Canada produces chlorine and hydrogen chloride at Fort Saskatchewan and is a supplier of methyl chloride, chlorobenzenes and chlorotoluenes in the States.

Hoechst is a manufacturer of chlorinated aliphatics and aromatics in both the U.S.A. and Europe.

Monsanto makes chlorobenzenes in the United States.

Union Carbide producers methyl chloride and methyl isocyanate in the United States.

Uniroyal Chemical's American parent makes some hydrazine hydrate at Geismar, La in order to have a captive precursor for its maleic hydrazide growth inhibitor as well as for the azodicarbonamide type blowing agents, antioxidants and stabilizers for the rubber and plastics industries.

3.5.0 Specialty products for explosives uses

One of the largest volume commodity chemicals produced in Alberta is ammonium nitrate, a substantial tonnage of which is a prill grade employed in industrial explosive rather than in nitrogen fertilizers. A large portion of the output from C-I-L's Carseland ammonium nitrate plant is exported to the coal mining regions in the western states as well as to companies servicing the hard-rock mines in the mountain states. By 1990 consumption of explosives in coal mines on both sides of the border could be double what is was during the 1970's. Moreover, slurries, though costing 2 to 3 times more than straight ammonium nitrate prills, have sufficient advantages in many operations to increase their market share.

3.5.1 The manufactured products

Water-gel explosives and slurry explosives incorporate a sensitizer such as **monomethylamine** and/or **trinitrolouene** (TNT) along with the basic ammonium nitrate.

Pentaerythritol tetranitrate is the prime material in detonator cords.

Hexamethylenetetramine, better known as hexamine, has been reviewed separately in Section 3.6.

The first slurry used commercially was made up of ammonium nitrate, coarse TNT and water and had to be employed with a booster (pentolite, cast TNT, etc.) because of its relative insensitivity. The addition of aluminum to the slurry augmented sensitivity and strength.

Composition of a typical water gel or slurry is as follows:

Ammonium nitrate	30-80%
Oxidizer:	
Sodium nitrate	10-15
Calcium nitrate	15-20
Sensitizer:	
Methylamine nitrate	<40
Trinitrotoluene	3-20
or pentolite, nitrostarch	
Aluminum	0-15
Gellants or thickeners	1-2
Stabilizer + antifreeze	1-15
Water	10-20

The large metal mines are normally supplied with bulk slurries from mixing plants operated by the explosives vendor. In addition, these vendors have one or more centrally-located plants in which they manufacture different sensitizers and also package various products (fuses, detonating caps, primer cord as well as formulated explosives).

Water gel and slurry explosives were developed to capitalize on the low cost of ammonium nitrate while increasing the available energy beyond that secured using ANFO (ammonium nitrate/fuel oil), improving initiability in small diameter charges, eliminating the problem associated with using ANFO in wet conditions and increasing field safety and economy. They are essentially thickened suspensions of oxidizers, fuels and a sensitizer dispersed in a saturated aqueous salt solution. As already noted, ammonium nitrate with or without other oxidizers make up that solution.

Guar gums, gelatin-forming compounds (carboxymethyl cellulose, etc.) and synthetic thickeners (polyacrylamides) are the gellants and can be crosslinked to control viscosity. Water resistance is enhanced through the use of hydrophilic colloids. And antifreezes such as glycerol, methanol or diethylene glycol are usually needed under northern winter conditions.

Slurries can be prepared hot in a plant and poured into lay-flat polyethylene bags for hand loading into boreholes. Alternatively they are bulk mixed in a plant, transported to the site of operations and pumped into boreholes after adding a thickening agent. Ireco recommends the use of a pump truck to do the mixing on site.

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+-----------------------------------------------------+
|                                                     |
|        EXPLOSIVES AND THEIR CONSTITUENTS            |
+-----------------------------------------------------+

Base chemicals        First-step intermediates

[Methanol]*---------------> [Formaldehyde]

[Formaldehyde]*+[Ammonia]*---> [Hexamine]

[Ethylene]*------------>[Acetaldehyde]

[Acetaldehyde]-------->]
                       ]-->[Pentaerythritol]
[Formaldehyde]*------->]

[Methanol]*+[NH3]---->  [Monomethylamine]

[Ammonia]+[Nitric acid]*--> [Ammonium nitrate]*


Intermediates        Explosives ingredient

[Hexamine]+[Nitric acid]*---> [Cyclonite]

[Pentaerythritol]*+[HNO3]*---> [Pentaerythritol nitrate]

[Monomethylamine]+[HNO3]---> [Methylamine nitrate]

+[Ammonium nitrate]*---->[Explosive slurries/gels]
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* already manufactured in Alberta

3.5.2 Alberta's strengths

An explosives manufacturer in Alberta should be in a better position to service the coal and metal mines in the western half of the continent than are its counterparts in eastern Canada or the United States.

Ammonia, the nitrogen source common to all explosives, is produced in a half dozen separate plants in Alberta. Each of these plants can count on a long-term supply of relatively low-cost natural gas. Nitric acid and ammonium nitrate are also manufactured in the province in large and efficient units.

The presence of two world-scale methanol plants in Alberta and the oxidation of some of this methanol into formaldehyde at two locations in the Edmonton area assures the availability of pentaerythritol and, potentially, of hexamine at a competitive cost.

Toluene is associated with the refinery reformate processed at Scotford (for benzene production).

3.5.3 Supply/demand balance

The demand for industrial explosives in Canada is well over 400 kt per annum, a reflection of the high level of mining activity in the country. About 20 to 24 percent of that demand is satisfied by slurries and gels.

Coal mining bulks much larger in the U.S.A. than in Canada. In fact, about two thirds of the industrial explosives used in the U.S. goes into the Appalachian, midwestern and Rocky Mountain coal mining operations. Explosives consumption in metal mining is in the 250-kt/year range. Another 300 kt/year or thereabouts go into non-metal mining, 200 kt into construction and another 150 kt into other applications. In 1981 the explosives market overall consumed two million short tons of ammonium nitrate with about 6 percent of that market supplied from Canada.

Slurry explosives have lost some market position in the past couple of years because metal mining has suffered proportionately more than has coal mining. Whereas in 1980 slurry explosives had 9.5 percent of the market (using U.S. Bureau of Mines data), the percentage fell to 9.2 in 1981 and even lower the following year.

Indicative of a widespread view that explosives will be manufactured in increased quantities for industrial purposes was a relatively recent Predicasts study which forecast that total U.S. demand for industrial explosives would rise from about 2 million tonne in 1980 to 4.2 million tonne in 1995. In the latter year, says Predicasts, ammonium nitrate-based explosives, which have almost completely supplant dynamite in blasting and industrial applications, will account for nearly 75 percent of the total. But if metal mining recovers from its current malaise and if slurry blasting agents continue their penetration into other markets, slurry and water gel demand is expected almost to triple to well over 500 kt/year by 1995.

3.5.4 Major suppliers

Borden Chemical, the formaldehyde producer outside of Edmonton, may have interest in making hexamine.

C-I-L manufactures most of its high explosives at Beloeil, Quebec, where it makes slurry compositions, TNT, PETN and other materials.

Cyanamid produces ammonium nitrate at Niagara Falls.

Du Pont Canada already makes water-gel explosives at North Bay, Ontario. Water gels are also prepared by E.I. du Pont at Biwabik, MN, Louviers, CO and Seneca, IL. PETN (pentaerythritol tetranitrate) is made at Louviers.

Hercules manufactures slurry explosives (and usually PETN as well) at Bessemer, Ala, Louisiana, Mo and Carthage, Mo.

Ireco Chemicals, the Gulf Resources subsidiary, prepares water gels and slurries at Bucknum, Wy and Columbus and Military, Kansas as well as in Jasper.

Nitrochem, which produces ammonium nitrate at Maitland, also controls Energy Sciences & Consultants, which makes water slurries at Biwabik, MN.

3.6.0 Other formaldehyde derivatives

Alberta, as a world supplier of methanol, should have formaldehyde costs lower than almost anywhere else in the world. Moving a 37% formaldehyde solution to market is, however, not as convenient as shipping the methanol to a point of use. Hence the formaldehyde production capacity in Alberta is sized to meet local requirements (mostly for the manufacture of pentaerythritol, plywood adhesives and urea-formaldehyde concentrates for coating urea fertilizer). Upgrading the formaldehyde to rather specialized products more readily transported could be a route to utilizing more methanol within Alberta's borders.

3.6.1 The manufactured products

Paraformaldehyde is the most widely used of the formaldehyde polymers. Trioxane, a crystalline cyclic trimer of formaldehyde, goes into the manufacture of polyacetals.

Paraformaldehyde, also described by chemists as a mixture of polyoxymethylene glycols, is essentially a low-molecular-weight polymer of formaldehyde. It is solid in form, soluble in both water and alcohols and therefore a convenient means of handling and transporting a product that normally is sold in relatively dilute aqueous form.

Theoretically anybody making formaldehyde from methanol has the option of taking the next energy-intensive step of concentrating the formalin to the paraform. Only one North American formaldehyde producer does so. In Canada there are four formaldehyde suppliers and none has yet been able to justify the investment required to make the solid concentrated product.

Hexamine, the reaction product of formalin and ammonia, is a catalyst and an explosives ingredient.

There is no great technical barrier to entry by any would-be supplier of hexamine. The chemical has been widely manufactured ever since World War II, the period in which hexamine was widely nitrated for use in RDX explosives.

Hexamine can be manufactured on a continuous or batch basis. The first stage involves use of a reaction kettle to combine the 37% formaldehyde solution with the ammonia. The reaction mixture is subsequently concentrated in a vacuum evaporator and the crystals centrifuged, washed with water and dried.

Pentaerythritol tetranitrate produced by nitrating another formaldehyde derivative, has other specialized uses in manufactured explosives.

Not only is pentaerythritol tetranitrate (PETN) one of the most brissant (describes shattering action) and sensitive of the military high explosives, but also it has a place in industrial explosives.

Not all of the companies committed to industrial explosives make their own PETN. In some cases the companies in the business can turn to other less-sensitive explosives (cyclonite or RDX is s prime example) or are satisfied to purchase PETN on a merchant basis.

PETN is manufactured by treating pentaerythritol with nitric acid. The nitrated mixture is dumped into a cold water bath and the PETN precipitates on a filter. The PETN is again washed in water and then dissolved in acetone. The solution is filtered and the PETN again precipitates by the addition of cold water. As it is separated, the PETN is caught on a filter and washed with water to remove the acetone. The tetranitrate is then held as a water-wet material until it is ready for use, at which time, the water is removed in a drying operation.

Polyacetals have long-chain oxymethylene groups (and possibly linkages provided by comonomer ethylene oxide) and are widely sold engineering resins.

Acetal homopolymers, notably the Delrin family developed by E.I. du Pont, consist of high-molecular-weight, stable, linear polymeric chains that are packed together into a highly ordered crystalline configuration. The basic Delrin resins differ in molecular weight, toughness having an inverse relationship with processability (melt flow).

The acetal polymers, pioneered by Celanese as an alternative to the Delrin, are prepared by copolymerization of trioxane with small amounts of a comonomer (usually ethylene oxide) randomly distributed in the polymer chain.

OTHER METHANOL/FORMALDEHYDE DERIVATIVES

Base chemicals First-step intermediates

[Methanol]*-------------> [Formaldehyde]

[Formaldehyde]*---------> [Paraformaldehyde]

[Formaldehyde]+[Methanol]---> [Formcels]

[Formaldehyde]---------> [Trioxane]

Intermediates Specialty products

[Trioxane]-------------> [Acetal homopolymers]

[Formaldehyde]*--------->

[Acetal copolymers]

[Ethylene oxide]*------>

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* already manufactured in Alberta

3.6.2 Alberta's strengths

In the long term, methanol costs in Alberta should be below those of any other North American price than that applying to shipments from the American Gulf Coast. A latent demand for paraformaldehyde may also exist in the western United States and in the Far East.

Hexamethylenetetramine is required as the curing agent for two-step phenol-formaldehyde resins in western market areas and must be imported from the eastern half of the continent. Any company making high explosives in the west should welcome a regional supplier of the hexamine.

California's expanding computer and telecommunications market for acetal parts could conceivably be satisfied, in part, from a western supplier.

3.6.3 Supply/demand balance

Canadian demand for hexamine has been in the 3 to 4 kt a year range. The consumption of hexamine in the States has been rather static at about 40 kt/year since 1977 whereas in 1974 production totalled over 66 kt. About 55 percent of the hexamine is used for phenolic resin curing, another 20 for NTA (nitriloacetic acid) production, 5 percent for cyclonite, 5 for pharmaceuticals and bactericides and 15 percent for miscellaneous applications.

The role of the merchant supplier of hexamine has been sharply restricted by the decline of a munitions market. The NTA producers make their own hexamine and presumably any wider acceptance of the chelating agent as a detergent builder would merely extend the practice of integrating hexamine manufacture with the synthesis of the nitrilotriacetic acid.

We estimate that about 800 tonne of pentaerythritol tetranitrate is produced annually at Beloeil. C-I-L consumes the bulk of the PETN it make in its own product line. However, a portion of its output does go to Du Pont at North Bay, Ontario. Annual demand for PETN in the U.S. is estimated at about 4,500 tonne.

Demand for PETN ebbs and flows with military requirements and the state of the mining industry. At the present time, consumption of PETN in industrial explosives (primarily blasting caps) is below par.

The North American consumption of paraformaldehyde has been static for years. Celanese operated its Bishop unit at high utilization rates during the 1960's but has elected not to do so ever since it closed down a vapor-phase oxidation unit there. One reason was a decision in the early 1970's to cease production of acrylates by the betapropiolactone process.

Demand of polyacetals in Canada has been as high as 1,200 tonne (in 1979) but currently is running at an annual rate of less than 1,000 tonne. This market is supplied from the U.S. by Celanese and Du Pont Canada as well as several distributors (Wilson Fiberfil is the largest of these). By 1987 the consumption of polyacetals in Canada should surpass 1,400 tonne/year. Annual American demand for polyacetals is probably about 45 kt. Consumer products absorb about 12 kt, another 10 kt go into plumbing and hardward, 9 kt into various industrial applications, and the balance into transportion, appliances, electrical/electronics and various sheet, rod and tube end-uses.

As with the suppliers of most engineering resins, the acetal vendors are able to develop new applications, albeit the expenditures on R&D are substantial. Price is a factor: designers will select cheaper materials unless the special characteristics of the acetals are essential in the application.

3.6.4 Major suppliers

Alberta Gas Chemicals makes methanol at Medicine Hat.

BASF is a polyacetals producer in West Germany.

Bakelite Thermosets makes formaldehyde and hexamine at Belleville, Ontario. It is also engaged in the production of resins for the waferboard industry.

Borden Chemical will soon be producing formaldehyde outside of Edmonton, where it also produces formaldehyde resins. Borden's parent has made hexamine in the United States.

Celanese Canada operates methanol and formaldehyde plants at Clover Bar and is the country's leading supplier of paraformaldehyde (from Texas) and the major source of acetal copolymers (Celcon) in the world. (It has subsidiaries in Japan and West Germany.)

Du Pont Canada markets the Delrin acetals made by its American parent. It is also involved in explosives and therefore is a consumer of hexamine.

Reichhold is the other hexamine producer in Canada (at North Bay, Ontario).

3.7.0 Surfactants and oilfield chemicals

The multiplicity of applications for surface-active agents in the resource industries together with the presence in Alberta of several key chemical intermediates or raw materials have undoubtedly been a signal to manufacturers of surfactants to look at Alberta as a location for one or more manufacturing operations. Such operations require a minimum scale beyond what would match the current demand in western Canada. They would also require the right cost equation for combining the long-chain hydrophobe (the "fatty" portion of the molecule) and the agents generally used for ethoxylating, sulfonating, amidating or quaternizing the hydrophobe.

3.7.1 The manufactured products

Ethoxylates can be either the non-ionic surfactants so widely used in industry (the liquid ethoxylated alkylphenols and, to a lesser extent, the solid ethoxylated alcohols are the basis of industrial cleaners, pulp-mill defoamers, oilfield demulsifiers, textile specialties, pesticide wetting agents) or the intermediates for the manufacture of anionic detergent-type sulfate.

Ethoxylates are essentially hydrophobes modified to include hydrophilic ether groups, the degree of ethoxylation being controlled to a desired level for a particular surfactant application. When the molecule is to be subsequently sulfonated (as is the case with the fatty ether sulfates), the mole substitution with ethylene oxide is relatively low. The hydrophobe can be one of several fatty substances. Primary and secondary alcohols are used for most detergent end-uses, but nonylphenol (and, to a lesser extent, octylphenol) is still the preferred hydrophobe for many industrial purposes. (The nonylphenol ethoxylate is an easy-to-handle liquid whereas the alcohol ethoxylate is usually a solid material.)

Ethylene oxide (EO) can be shipped, although with much care, but generally the ethoxylators like to be reasonably close to the EO supplier. In some countries, the EO vendor is also an ethoxylator in its own right. The hydrophobic portion of the surfactant molecule usually involves longer supply lines because the fatty materials are more readily transported.

The ethoxylation of an hydrophobe is normally carried out on a batch basis in large kettles. Precise control systems are required to assure the hydrophilic functionality desired.

Sulfonates, including the large-volume dodecylbenzene sulfonates, alpha-olefin sulfonates and the fatty-alcohol sulfates and ether sulfates, are the mainstays of the detergent industry. **Petroleum sulfonates** are regarded as the lowest-cost candidates for enhanced oil recovery based on detergent action of water flushed through petroleum reservoirs.

Ethanolamides are most widely used foam enhancers in detergent formulations.

Fatty amines and **quaternary ammonium compounds** represent a different family of surfactants (cationic or amphoteric in nature) with very widespread consumer (fabric softening) and industrial application. The amines also yield **imidazolines,** which are equally as sophisticated in surfactant application.

The polymerization of ethylene oxide and/or propylene oxide and the modification of terminal groups by substitution with one or more alcohols yields polyols that are not necessarily sold as a polyurethane precursor. Some of these non-urethane **polyethers** have become the accepted surfactant for demulsifier use in petroleum production and refining.

These polyoxyalkylene derivatives of ethylene glycol and/or propylene glycol are distinct from the wide range of liquid and solid polyethylene glycols (PEG) typified by Union Carbide's Carbowax series, the polyether polyols that provide the functional hydroxyl groups for urethane polymers or the ethylene oxide polymers sold by Union Carbide as Polyox.

(Meisel Chemical Works and Seitetsu Kagaku of Japan also make the higher molecular weight polyethyleneoxide used in water-soluble packaging film, adhesives, etc.) They are, however, also non-volatile, non-corrosive materials.

Polyethylene glycols, diethylene glycol and glycerin are key ingredients (along with fatty acids, etc.) in the formation of compositions useful for oilfield corrosion inhibitors as well as products useful in the food and cosmetics field.

Diethylene glycol (DEG) is also the starting point in a process that yields both **diethylene glycolamine** and **morpholine.** The former product is employed in some gas processing plants and the latter is, among other things, an oxygen scavenger in boiler water.

Morpholine, which can be described chemically as tetrahydro-1, 4-oxazine, is an amino ether. It participates in most reactions through its secondary amino group. The morpholine is a mildly basic ammoniacal liquid, colorless, mobile, hygroscopic and with a characteristic odor.

Very few manufacturing units are required to satisfy world demand for this organic specialty, in large part because a 10-kt/year plant is now considered minimum scale.

For many years the dehydration of diethanolamine was the major process for making morpholine. After Dow and Union Carbide ceased production in the early 1970's, Texaco's Jefferson Chemicals affiliate became the sole U.S. producer utilizing a process based on DEG, ammonia and a small amount of hydrogen. Air Products, currently building a commercial unit at Pace, Florida, also uses DEG but has reportedly developed some novel low-pressure technology. Air Products claims that its proprietary catalyst not only functions in low-pressure equipment commonly used for its production of alkylamines but also minimizes production of byproducts. With the higher severity involved in the Texaco route, N-alkylmorpholines are generated and must be separated (though they are useful as urethane catalysts). In producing morpholine, the precursor or coproduct 2-(2-aminoethoxy) ethanol -- also known as diethylene glycolamine -- can also be separated and sold for gas conditioning purposes.

OIL-FIELD SPECIALTY SURFACTANTS

Base chemicals First-step intermediates

[Ethylene oxide]*--------------->[Polyethylene glycols]

[Ethylene oxide]*----------------> [Diethylene glycol]

[Propylene]---->[Nonene]+[Phenol]---->[Nonylphenol]

[Ethylene]*------------------>C12-C14 olefins,alcohol

Intermediates Specialty products

[Diethylene glycol]+[Ammonia]*->[Diethyleneglycolamine]

[Diethyleneglycolamine]--------> [Morpholine]

[Ethylene oxide]+[Nonylphenol]------>[Nonylphenol ethoxylates]

[C12-C14 alpha-olefins]+[EO]+[SO3]-->[Alcohol ether sulfates]

[EO]+[C12-C14 alcohols]--------> [Alcohol ethoxylates]

[Coconut fatty acid]+[EO]------> [Fatty acid ethoxylates]

[Tall oil fatty acid]+[EO]-----> [TOFA ethoxylates]

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* already manufactured in Alberta

3.7.2 Alberta's strengths

A world-scale supplier of ethylene oxide and the prospect of a second company making EO available for ethoxylations should guarantee to any surfactant producer in Alberta that at least one cost constituent is satisfactorily low.

The manufacture of polyethylene glycols would be a straight forward operation in Alberta because of the availability of EO. About $2 million worth of polyethylene glycols are imported into western Canada annually -- presumably because of their utilization in oilfield specialties.

Though almost all hydrophobes would be imported at this point in time, the supply of local tallow could be augmented and tall oil could be fractionated for its fatty acid content. Application has been made for permission to build an alpha-olefins plant in Alberta, and refinery propylene is available for trimer nonene production. Moreover, fatty amines are made in Saskatchewan and could possibly be made in Alberta (which has so much ammonia production) as well.

If sulfonation is required, the operator of a Chemithon-type unit could look forward to competitive sulfur costs. Quaternization of fatty amines could be practical if methyl chloride, the most widely used quaternizing agent, were made in Alberta.

There is a regional market for surfactants incorporated in oilfield specialties (notably demulsifiers and corrosion inhibitors) and in pulp-mill products.

Many regions along the Pacific Rim (including California) are net importers of surfactants or of detergents incorporating surfactants. They represent possible markets for competitively-priced product made in Alberta.

Adoption of surfactants as an agent in enhanced oil recovery could open up a large-volume local market for petroleum sulfonates.

3.7.3 Supply/demand balance

The need for a rough balance between supply and demand to achieve price stability applies primarily at the raw materials level since the cost of the ethylene oxide and hydrophobes constitute so large a fraction of the total manufacturing costs of the ethoxylates. The ethoxylators aren't usually saddled with oppressively heavy overheads. They continue to function in a growth industry (increasing at a rate of between 3 and 4 percent) and seek to find some niche in the marketplace.

Scale of manufacture is seemingly not of vital importance in the manufacture of surfactant polyols. Among them the four U.S. producers operate eight plants from the Gulf Coast to California. Demand is, of course, related to activity in the petroleum industry. One forecast puts growth at 4.4 percent per year for all polyol-type surfactants.

Canadian industry is a relatively small consumer of morpholine and of diethylene glycolamine. Imports of morpholine from the United States and West Germany reached 677 tonne in 1981 but declined to 504 tonne in 1982 and will probably exceed 800 tonne in 1983. Most of the morpholine is consumed as a corrosion inhibitor in boiler feedwater. The U.S. market for morpholine has been in the 11 to 12 kt/year range for the last few years after approaching 14 kt in 1979. There isn't much reason to believe that it will return to the 1979 level during the current decade.

When Air Products completes its Pace expansion in 1984, there will be considerable oversupply. Texaco will undoubtedly forgo any production of morpholine at Conroe. It does have its Welsh plant (at Llanelli) to fall back on if Port Neches runs into trouble. BASF-Wyandotte had made noises about making morpholine in North America (especially in 1979) but seemingly has given up any plans to do so.

3.7.4 Major suppliers

Air Products has entered into the production of morpholine in Florida in competition with Texaco and BASF.

Alkaril Chemicals manufactures ethoxylates, imidazolines and a wide range of specialty surfactants in Mississauga, Ontario. Alkaril has diversified into polyols.

BASF Canada distributes morpholine manufactured by its West German parent. BASF-Wyandotte in the U.S.A. is the leading producer of polyol-type surfactants.

Baker International (the Magna people) manufactures, in two U.S. locations, polyols used for demulsifiers and other surfactant functions.

Berol Kemi, an ethylene oxide producer in Stenungsund, Sweden, makes ethoxylates and imidazolines there for many end-uses (including pulp and paper specialties, herbicides, ore flotation and coal slurrying).

Conoco (now Vista Chemical) has been a major supplier of detergent alkylate, fatty alcohols and ethoxylates in the United States.

Domtar's organic chemicals division makes ethoxylates, sulfonates, quaternary ammonium compounds, etc. at Longford Mills, Ontario.

Dow Chemical Canada is basic in ethylene oxide.

Ethyl Canada markets the fatty alcohols manufactured by its American parent.

Hart Chemical ethoxylates at Guelph, Ontario and is associated with Lever Detergents, which has a Chemithon unit in Toronto.

Nalco, which has corporate links with Alchem in Canada, manufactures polyols and other oilfield specialties in the U.S. Vischem is its formulating outlet in Alberta.

Petrolite is another U.S. oilfield specialties company making polyols in three locations south of the border.

Rohm & Haas is the largest U.S. source of alkylphenol-based surfactants (the Triton series).

Shell Canada Chemical has access to the Shell SHOP technology that has put Shell internationally into alpha olefins and fatty alcohols. In the U.S.A., Shell also makes ethylene oxide and does bulk ethoxylations.

Union Carbide Canada is the other ethylene oxide supplier in Alberta. The company has done ethoxylations in Canada and also does so in West Virginia. Essentially though it is a merchant supplier of EO. Carbide is also a major supplier of polyols for non-surfactant applications.

Witco Chemical makes polyols for demulsifier use in south of the border.

3.8.0 Derivatives of tall oil

All of the tall oil recovered from kraft-mill cooking liquors in western Canada is exported in crude form to the U.S. fractionators.

The fractionation of crude tall oil from western pulp mills may not only be a commercially feasible project in its own right but also would provide a source of fatty acids for possible surfactant and/or polyamides production in Alberta.

3.8.1 The manufactured products

Crude tall oil (CTO) is a byproduct of the sulfate (kraft) process for making wood pulp. In this process, wood chips are cooked in digesters in a mixture of caustic soda and sodium sulfide, producing a "black liquor" made up of lignin, rosin and fatty acids. The tall oil components are skimmed from the liquor, with sulfuric acid (either by the producing pulp mill or, more commonly, at an acidulation facility serving several pulp mills), and shipped to a CTO fractionation plant.

CTO is first vaporized in a stripping tower to remove the tall oil pitch component and distilled tall oil. The bulk of the mix then goes to a rosin tower where the fatty acids and rosin constituents are grossly separated and the two streams fed to stainless steel fractional distillation towers operating under vacuum at temperatures between 200 and 285 C. Rosins and fatty acids of varying quality emerge at different boil-out temperatures. High-purity fatty acids may go through up to three distillations. Subsequent fatty acid treatment involves chemical and physical measures and clay bleaching to produce material of the desired quality. These processes are proprietary. One modern fractional distillation process is the West German Luwa process which reportedly provides substantial energy savings over traditional techniques.

The supply of TOFA and rosin constitutes between 55 and 60 percent of processed crude tall oil (probably 45 to 55 percent from northern tree species). The rest is discarded as waste.

Fractionators sell most of the recovered fatty acids and rosin to others for further processing, although some convert the rosin portion to paper size, a major end-use.

Rosin acids are the base of most paper sizing compositions. A heavy cut, **pitch** is the byproduct of a first refining step. It can be used in asphalt compositions.

The volume of rosin produced from steam-distilled wood chips derived from old pine tree stumps and logging waste is currently 100 kilotonne a year, compared to about 200 kt of rosin (in the early 1960's, these volumes were reversed). While only about 6 kt of gum rosin -- extracted from living softwood trees -- is produced in North America, there are substantial imports from China and Portugal.

The C18 acids, generally known as **tall oil fatty acids** (TOFA), are intermediates in the production of dimer acids (see below), epoxides, surfactants and alkyd resins as well as also being a flotation reagent.

Dimer acids are used in polyamide resins. Dimer acid is the name given to a high molecular weight dibasic acid which is a viscous liquid, stable, resistant to high temperatures. It is produced by dimerization of unsaturated C18 acids. Most dimer acid also includes from 13 to 23.5 percent trimer, which contains three carboxylic groups and 54 carbons.

The polyamides of commerce fall into three categories. The condensate of ethylenediamine and dimer acid produces a non-reactive thermoplastic useful in adhesives and a range of other applications. Using diethylenetriamine instead of the EDA results in a reactive polyamide that copolymerizes epoxy resins. Another reactive type involves the reaction of adipic acid and diethylenetriamine prior to the combination of the polyamide with epichlorohydrin. These so-called PEC resins are employed primarily for increasing the wet strength of paper products.

The United States is a net exporter of dimer acid and polyamides because of its massive tall oil industry. Probably 3 to 4 kt of polyamides are exported annually.

The non-saponifiable **low boilers**, or "heads", are sold as low-cost solvents.

The fractionator's heavy ends, are sold as **distilled tall oil.**

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+----------------------------------------------------+
|                                                    |
|        TALL OIL DERIVATIVES                        |
+----------------------------------------------------+

Base chemicals          First-step intermediates

[Kraft-mill cooking liquor]*+[H2SO4]*------>[Tall oil]

[Tall oil]--->[Rosin acids]+[TOFA]+[Low boilers]+[Pitch]

Intermediates                       Specialty products

[Rosin acids]+[Caustic soda]*---------->[Paper sizing]

[Rosin acids]+[Alkali]-------------------->[Resinates]

[TOFA]+[Caustic soda] ---------------->[Tallate soaps]

[TOFA]+[Caustic potash]--------------->[Liquid soaps]

[TOFA]+[Phthalic anhydride]+[Pentaerythritol]---->
                                          [Alkyd resins]

[TOFA]+[Ethylene oxide]*------> [Tall oil ethoxylates]

[TOFA]--->[Dimer acids]+[Ethylenediamine]->[Polyamides]

[Low boilers]-------->[Solvent blends]

[Distilled tall oil]------->[Rubber tackifiers]

[Pitch]----------------->[Asphalt compositions]
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* already manufactured in Alberta

3.8.2 Alberta's strengths

A sizeable tonnage of unprocessed tall oil is within easy shipping distance of any potential fractionating unit.

Most rosin size requirements in Canada are based either on imported rosin or the foreign supplies of the formulated size. This reliance on imports is virtually complete in the western provinces.

Energy costs for the distillation of the tall oil are especially attractive in Alberta because of its natural gas reserves.

Low energy prices also opens up the possibility of even finer separations of the tall oil constituents, including possible fractionation of the heads and pitch.

Japan may be an outlet for tall oil fractions in the same way it is the recipient today of the crude tall oil.

3.8.3 Supply/demand balance

CTO fractionation capacity in the U.S. appears adequate to serve domestic and export market demand well into the future. Capacity utilization in 1979 and 1980 dropped to 75 percent in 1981, rebounding to 80 percent in 1982. Recent permanent withdrawal of 125,000 tonne of capacity, coupled with forecasts of an essentially flat tall oil product demand, should result in a 90 percent capacity utilization rate through 1990.

In view of the substantial CTO refining over-capacity in the U.S. throughout the 1970's, it is interesting that Georgia-Pacific deemed a new 35 kilotonne plant (opened in 1981) to be a viable proposition. There were obviously factors at work other than market demand. Perhaps a substantial part of the TOFA and/or rosin output is used captively.

In Canada, the lone 18-kt/year Hercules CTO fractionation plant in Ontario is able to meet only about half of Canadian TOFA and much less of rosin demand. Imports, nearly all from the U.S., take up the slack. Product yield from CTO at Hercules plant is 45 to 50 percent. There appears to be room for another Canadian plant of at least 20,000 tonne, based on Canadian demand alone, perhaps larger with prospective export markets.

Because TOFA and rosin are coproducts, and because both face competition from substitutes, severe distortions in the markets for either product has an impact on production and demand for both products. For example, in 1983 large increases in U.S. imports of gum rosin from China and Portugal have depressed demand for U.S. tall oil rosin both domestically and in exports markets, with resulting inventory buildup. In turn, this has led to inventory-control cutbacks in rosin production and thus unavoidably in TOFA production. Prices of CTO and rosin have fallen because of lower demand.

Historically, there have been no abrupt shifts in demand for TOFA and rosin, despite a long-standing tendency to volatility in prices. Demand holds up even if profits do not. This is because tall oil product prices move in tandem with the higher-priced, price-setting tall oil substitutes, e.g. animal and vegetable fatty acids in the case of TOFA and gum and wood resins in the case of rosin.

3.8.4 Major suppliers

Emery Industries is a leading North American supplier of fatty acids from various sources. It was until recently a partner with Monsanto in a Nitro, West Virginia tall oil fractionator.

Erco Industries' Tenneco affiliate is involved in paper size supply in eastern Canada.

Georgia Pacific fractionates tall oil at Plaquemine in Louisiana.

Hercules Canada has the strongest position in tall oil derivatives. It fractionates at Burlington, Ontario and its parent has plants in Portland, Ore, Savannah, Ga and Hattiesburg, MS.

Monsanto Canada makes size at Montreal and was a partner with Emery in a tall oil plant at Nitro.

3.9.0 Derivatives of ethylenediamine

With both ethylene dichloride and ammonia made in world-scale plants in Alberta, there is no question that ethylenediamine and its derivatives could be produced on a cost competitive basis in the province. The question becomes one of whether or not getting these derivatives to market is profitable.

3.9.1 The manufactured products

Ethylenediamine is the stepping stone to a wide range of specialty chemicals. It is a hygroscopic, water soluble, slightly viscous liquid with a strong ammoniacal odor. It is used almost exclusively as an intermediate. Homologs diethylenetriamine, triethylenetetramine, tetraethylenepentamine and pentaethylenehexamine are similar in appearance and properties.

North America is a net exporter of ethylenediamine. Indeed, of the 30,000 tonne of EDA produced annually in the U.S.A., about 8 to 9,000 tonne are exported. However, expansions by Dow Chemical and BASF in Europe have increased capacity in Europe so that movement of EDA in that direction will obviously diminish.

EDA and its higher homologs are produced by reacting ammonia with ethylene dichloride (EDC) in the liquid phase. An alternate process employed by Union Carbide to produce some EDA is the reaction of ammonia with monoethanolamine, which is made by the reaction of ammonia and ethylene oxide. While the EDC route yields a mixture of EDA with higher amines, the ethanolamine approach is reportedly more selective for EDA with smaller quantities of the higher homologs produced. The product of the the EDA/EDC reaction is in the form of ethylenediamine hydrochlorides, which are then neutralized with caustic soda. The mixture of amines is separated by fractional distillation while ammonia is recovered and recycled.

The availability of lower-cost ethylenediamine in Alberta would have a salutorious effect on the economics of making chelating agents there. These ethyleneamines-based chelating agents, often referred to as edetic acids, have wide application in resource industries using large quantities of process water.

EDTA, the reaction product of EDA with formaldehyde and hydrogen cyanide to form **ethylenediamine tetraacetic acid**, is probably the most widely used sequestering agent (usually as the tetrasodium salt). The EDTA manufacturer normally buys byproduct hydrogen cyanide from an acrylonitrile producer and combines it with a caustic solution to form the cyanide. Homolog diethylenetriamine is the precursor to the pentasodium salt of diethylenetriaminepentacetic acid (DTPA), another "edetic acid" used as a chelating agent.

The more common edetic acids are normally produced on a batch basis so that scale is not an overriding factor. The chelating agents are sold both as solutions and as a 100 percent powder.

The most popular route to EDTA salts is via the reaction of ethylenediamine, sodium cyanide and formaldehyde.

Ethylene bisdithiocarbamate fungicides (nabam, zineb, maneb) are produced by reacting EDA with carbon disulfide.

Imidazolines are derived from ethylenediamine (usually as the aminoethylethanolamine derivative) and appropriate fatty acids.

Polyamide resins are formed by combining EDA with dimer acids secured from tall oil fatty acid.

ETHYLENEDIAMINE AND DERIVATIVES

Base chemicals First-step intermediates

[Ethylene dichloride]*+[Ammonia]*---> [Ethylenediamine]

[Methanol]*---------------------> [Formaldehyde]*

Intermediates Specialty products

[Ethylenediamine]-------------->[Aminoethylethanolamine]

[Aminoethylethanolamine]+[Fatty acid] -->[Imidazolines]

[EDA]+[Formaldehyde]+[Sodium cyanide]---> [Sodium ethylenediamine tetraacetate]

[EDA]+[Dimer acid]-----------------> [Polyamide resins]

[EDA]+[Carbon disulfide]*----------> [Ethylene bisdithiocarbamate]

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* already manufactured in Alberta

3.9.2 Alberta's strengths

Both ethylene and ammonia, the two key building blocks for the manufacture of EDA and its derivatives, should continue to have lower production costs in Alberta than in just about any other North American location.

The two alternative ethylene derivatives used for EDA manufacture -- i.e. ethylene dichloride and monoethanolamine -- are currently being made at Fort Saskatchewan.

Formaldehyde, required for EDTA production, is manufactured at two Alberta locations and is based on low-cost methanol. Energy-intensive hydrogen cyanide could be generated at a reasonable cost. (Chloroacetic acid may be a satisfactory alternative reagent.)

Various hydrophobes (including dimer acid and stearic acid) will become increasingly available in Alberta.

EDTA sequestering agents have a ready market in the resource industries spread throughout western North America.

Imidazolines are employed in corrosion inhibitors for oilfield use and could conceivably be competitive in the California market, where fabric softener demand is substantial.

Polyamides are finding more application in water treatment and in wet-strength paper additives, applications which expand the demand for the resins in western markets.

3.9.3 Supply/demand balance

The 1982 consumption of EDA in the U.S. was just over 20 kt, a level that existed as far back as 1965. Demand will come back somewhat and should be at about 27 kt/year by 1987. The declining use of the thiocarbamate-type fungicides and of dimethylolethylene urea (DMEU), the reaction product of formaldehyde and EDA, as a cotton textile crease-proofing agent, has offset growth in demand for EDTA chelating agents, polyamides and amine polyols.

Carbide's expansion of EDA capacity at Texas City and construction of a new unit at Taft in late 1980's were hardly justified by any show of strength in the marketplace. The upshot is capacity for EDA and the higher homologs well in excess of demand.

Imports of edetic acid to Canada were reportedly 1,235 tonne in 1981 (worth $1.18 million) and 1,114 tonne in the following year. Demand in the U.S.A. for EDTA alone is close to 40 kt per annum. EDTA chelating agents experienced average annual growth in the U.S. of 7 to 8 percent during the 1970's and early 1980's. That pace will probably be moderated during the balance of the decade but a 5 percent annual increment is quite likely.

Chelating agents are so versatile that new applications emerge regularly. In Canada the pulp and paper industry has been an important customer (this is especially true for the pentacetic DTPA) and will probably increase its usage as more mill water systems are closed up.

Consumption of polyamides in North America is currently in the 15 to 18 kt/year range. Another 13 to 15 kt were the reactives used as curing agent for epoxies. And approximately 10 to 12 kt were PEC resins consumed by the paper industry. Global demand for epoxy resins has continued to grow as more sophisticated reinforced plastics components and specialty maintenance coatings are developed. Hot-melt adhesives are still gaining market share. And the PEC resins are rapidly displacing the urea-formaldehyde types as the wet-strength additive in paper products now that the Hercules patents no longer constrain supply and price.

3.9.4 Major suppliers

Alkaril Chemicals is a producer of imidazolines in Mississauga, Ontario.

Berol Kemi of Stenungsund, Sweden, has a proprietary process for the manufacture of ethylenediamine and its derivatives. It also makes imidazolines there.

Borden Chemical purchases polyamides to make wet-strength paper additives in eastern Canada. The company has a formaldehyde plant outside Edmonton.

Dow Chemical already manufactures EDA on the U.S. Gulf Coast (Freeport) and in the Netherlands. It makes ethylene dichloride at Fort Saskatchewan. It is also a manufacturer of EDTA in the United States.

Hart Chemical markets EDTA sequestering agents made by Dow Chemical.

Henkel Chemical is a world supplier of the Versamid polyamides.

Union Carbide Canada is privy to an EO supply at Prentiss and to its parent's EDA technology.

Uniroyal has expertise in thiocarbamate manufacture and has also manufactured chloroacetic acid in an Edmonton site which it still owns.

3.10.0 Cellulosic water soluble polymers

Cellulose ethers are chemically modified cellulose products (usually from wood pulp) used essentially for viscosity adjustment in a wide range of industrial, food and pharmaceutical products and processes. Alberta is a large consumer of several cellulose ethers in drilling muds.

Cellulose ethers are chemically modified cellulose products (from wood pulp or cotton linters) used essentially for viscosity adjustment in a wide range of food, pharmaceutical as well as industrial products and processes. There are ten different cellulose ethers, the names of which identify their chemical nature:

MC: methylcellulose

HPMC: hydroxypropylmethylcellulose

HBMC: hydroxybutylmethylcellulose

HEMC: hydroxyethylmethylcellulose

HEC: hydroxyethylcellulose

EC: ethylcellulose

EHEC: ethylhyroxyethylcellulose

CMC: carboxymethylcellulose

CMHEC: carboxymethylhydroxyethylcellulose

HPC: hydroxypropylcellulose

3.10.1 The manufactured products

Carboxymethylcellulose is manufactured by spraying powdered cellulose with a caustic soda solution and reacting the alkali cellulose with chloroacetic acid.

Carboxymethylcellulose (CMC) is one of several water-soluble cellulose ether products whose primary function is vicosity adjustment. CMC, more correctly the sodium salt of the carboxylated cellulose, is sold as a granulated white powder and comes in four broad grades defined by CMC concentration: crude, or detergent (55 percent CMC) and technical. Encompassed by these grade classes are some 250 products with varying viscosity ranges (5 up to 75,000 CPS at 20 C.) and other technical property differences suited to specific end-uses.

It is estimated that 30 to 35 percent of world output of CMC is in high-purity grades, i.e. having 99 percent CMC or better. Until 1982, Hercules was the sole U.S. producer of high-purity grade material used by food, pharmaceutical, toiletry and oil-well drilling industries. In 1982, tiny Louisiana Cellulose entered the high-purity market at the same time increasing its plant production capacity to between 1 and 2 kt. Domtar in Canada also makes some food-grade CMC, but no more than 100 tonne a year.

The essential steps in converting cellulose to CMC are the same in all production plants even though considerable procedural and equipment differences exist. High-alpha cellulose (wood pulp or cotton linters) is alkalized by exposure to caustic soda (sodium hydroxide) at about 20 percent solution. The alkali cellulose is methoxylated with monochloroacetic acid (MCA usually converted in situ to salt, sodium chloroacetic acid) to partially replace in the cellulose molecular structure with carboxymethyl groups. MCA concentration use depends on the degree of substitution (DS) of the hydroxyl groups, which determines the essential properties of the CMC.

Methyl cellulose is more correctly a cellulose methyl ether derived from treating alkali cellulose with methyl chloride, dimethyl sulfate or methanol.

Hydroxypropyl methylcellulose is a variant of methyl cellulose in that the etherifying agent is propylene oxide.

Hydroxyethyl cellulose is a competitive product in which ethylene oxide is the key reagent.

Solubility is an important controlling factor in cellulose ether applications. EC and EHEC are solvent-soluble and all the other products are only water-soluble. HEC and HEMC are soluble in both cold and hot water, while MC, HPMC and HBMC are soluble only in cold water. The water soluble products have the unique property of thermal gelation, being able to reverse the change from solutions to gels at specific temperatures.

Cellulose ethers are sold commercially on the basis of viscosity rating. In MC, for example, viscosities range from 15 to 4,000 cp (at 20 C.), while HPMC viscosities encompass a range of 5 to 75,000 cp.

All cellulose ethers utilize wood pulp or cotton linters as the starting raw material. In all cases, the cellulose -- which preferably has a high alpha-cellulose content -- is alkalized by dipping, spraying or steeping in 35 to 60 percent aqueous caustic soda (sodium hydroxide) in a reactor vessel under pressure. This treatment determines the final viscosity of the cellulose ether products, which can be controlled by the cellulose grade and the length of aging (12 to 20 hours) of the alkalized pulp.

The pulp is then chemically reacted in a closed, heated vessel with maximum pressure of 1.38 MPA (200 psig) so as to cause a partial substitution of the three hydroxyl groups in the cellulose molecular structure. The degree of substitution (DS) determined the properties of the final cellulose ether product and is generally in the range between 0.4 to 1.2 (of a maximum of 3, corresponding to the maximum of three hydroxyl groups available for substitution).

The reactant chemical determines the chemical nature of the final product. In the case of MC, the reactant is methyl chloride, resulting in a methoxyl substitution of 26 to 33 percent. In the case of HPMC, propylene oxide is employed along with methyl chloride for the reaction. Similarily, butylene oxide is used with methyl chloride for HBMC and ethylene oxide for HEMC. The amount of chemical reactant(s) and reaction time, temperature and pressure control the precise properties of the final product.

For HEC, ethylene oxide is used as the reactant while for EC the reactants are ethylene chloride and benzene.

Recoverable byproduct streams from MC production are dimethyl ether and methanol. From HEC production, ethylene glycol and ethers of ethylene glycol can be recovered.

The cellulose ether products are washed up to five times in dilute organic solvents like methanol to remove trace impurities and are then dried, sized, ground and packaged.

WATER-SOLUBLE POLYMERS

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Base chemicals          First-step intermediates

[alpha-Cellulose]+[Caustic]*--> [Alkali cellulose]

[Acetic acid]*+[Chlorine]*-----> [Chloroacetic acid]

[Methanol]*+[Chlorine]*--------> [Methyl chloride]

[Propylene]+[Chlorine*/oxygen]->[Propylene oxide(PO)]

[Propylene]+[Ammonia]*--------->[Acrylonitrile]

[Propylene]------------------->[Acrylic acid]


Intermediates               Water-soluble polymers

[Cellulose]+[Chloroacetic]--->[Carboxymethylcellulose]

[Cellulose]+[Methyl chloride]------>[Methyl cellulose]

[Cellulose]+[PO]------->[Hydroxypropylmethylcellulose]

[Cellulose]+[Ethylene oxide]---->[Hydroethylcellulose]

[Acrylonitrile]---->[Acrylamide]---->[Polyacrylamides]

[Acrylic acid]------------------------->[Polyacrylics]
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* already manufactured in Alberta

3.10.2 Alberta's strengths

Though no dissolving pulp is actually produced in an Alberta mill, the alpha-cellulose arrives in the Edmonton area in large volumes and at a relatively good cost.

An acetic acid plant operates at Clover Bar and there is the possibility that an even larger unit, based on methanol, will be built there as well. Any methanol required for methyl chloride readily obtainable from two world-scale plants in the province. Ethylene oxide is also locally available for any hydroxyethyl cellulose that might be made. Caustic soda, required for digestion of the cellulose, is manufactured at Fort Saskatchewan.

The manufacture of CMC usually involves drying and salt extraction operations that entail the use of energy. So, Alberta's low fuel costs are a distinct advantage.

Any CMC producer would have a significant local market (CMC is a thickening agent for drilling muds) and proximity to the Saskatchewan potash mines, some of which use the gum for their flotation circuits. Hydroxyethyl cellulose (HEC) has efficacy in oilfield specialties as well. (The other big market area for HEC is in latex paints.) Usage in the United States of HEC in oilfield workover fluids and cements was expected to exceed 6,000 tonne in 1984.

3.10.3 Supply/demand balance

Capacity utilization of American CMC plants was 70 percent in 1979 and 62 percent in 1982, with reduced oilwell drilling and textile industry activity contributing largely to the poor 1982 showing. Capacity utilization in 1984, after taking into account the permanent withdrawal of 10,000 tonne of capacity in 1983, will nudge 90 percent if 1984 demand projections prove accurate.

Of the 4 to 5 kilotonne of American CMC imports during 1981, 2.7 kt came from European suppliers. These suppliers showing considerable interest in the U.S. market, even to the extent of reportedly considering new plant construction there. The precise factors that make these relatively large volumes of imports feasible in the face of underutilization of capacity have not been fully determined. Certainly in the case of Finnish exports to Canada, competitive pricing appears to be the decisive influence.

Dow insists that there is at present production overcapacity in methyl cellulose and maintains that this will continue indefinitely. Data shown above indeed point to a 70 percent MC capacity utilization in 1979. And if Dow pursues all phases of a 7,000 tonne MC expansion announced in 1981, capacity utilization will remain at 70 percent in 1984, despite a projected 25 percent increase in demand. Compounded annual growth in MC demand is put at 4.6 percent.

It may be significant that Henkel of West Germany has never proceeded with construction of an MC plant in the U.S. for which it was developing plans in 1978. Henkel has since become an aggressive participant in the U.S. market via imports.

Hydroxyethylcellulose capacity utilization in the U.S. in 1979 was 85 percent. The U.S.A. accounts for half of world output. If projections of American HEC demand during 1984 prove correct, supply and demand will be exactly in balance, provided no new capacity is added meanwhile -- and none is planned so far as can be ascertained. Any temptation to increase HEC capacity in the States could be tempered by the fact that, during 1982, HEC capacity utilization worldwide was only 75 percent.

The brightest prospect for growth in HEC demand in the U.S. is in oilfield workover fluids and cements, where demand is expected to double to more than 6,000 tonne by 1984. Surface coatings (especially latex paints), the major HEC market, is projected to grow at 4 percent annually through 1984, while other applications will enjoy a 3 percent annual growth.

3.10.4 Major suppliers

Akzo is the Dutch producer of CMC. Its product line has been sold in western Canada.

BP Chemicals made hydroxyethylcellulose in Belgium.

Berol Kemi of Sweden manufactures ethyl cellulose.

Celanese Canada has the best raw-material position because it already processes cellulose and makes acetic acid at Clover Bar. An associated company makes CMC in Mexico.

Domtar is Canada's sole CMC producer. Its plant in Longford Mills, Ontario has serviced the eastern Canadian demand for CMC used in detergents, foods and textiles.

Dow Chemical will be making 19 kt per year of methyl cellulose at Midland, Mich by 1985 and it is expanding methyl cellulose capacity at Plaquemine, La to 6 kt/year. Dow has ethylene oxide available at Fort Saskatchewan if HEC were to be made in Alberta. Dow has an European methyl cellulose plant (in Stade, West Germany) as well.

Henkel makes methyl cellulose in Dusseldorf, West Germany and in Doel, Belgium.

Hercules is a producer of both CMC and hydroxyethylcellulose at Hopewell, Va and HEC alone at Parlin, New Jersey.

Hoechst produces methyl cellulose and hydroxyethyl cellulose in Wiesbaden, West Germany.

Metsaliiton of Finland is a major supplier of CMC in western Canada.

Shin Etsu Chemical Products of Japan manufactures methyl cellulose and hydroethylcellulose.

Uddeholm Chemicals of Skoghall, Sweden is a CMC producer represented in Canada.

Union Carbide makes HEC at Institute in West Virginia.

3.11.0 Other water-soluble polymers

Water-soluble polymers based on the vinyl double-bonded linkage have displaced natural gums and inorganic products in a number of water conditioning functions.

3.11.1 The manufactured products

Acrylamide copolymers can include acrylic acid, methacrylic acid or their esters as the other monomer. Polymerizing acrylamide alone can also yield a solid electrolyte as well as low-molecular-weight liquids.

Often referred to as polyelectrolytes, the polymers of acrylamide with or without a comonomer are the most widely used organic flocculants for solid-liquid separation systems and also function as an efficient dispersant. They should have an even larger role in the western resource economy in future years.

Polymerizing acrylamide alone yields a nonionic material which can be either liquid or solid (depending on the degree of polymerization). In this case the polyelectrolyte label is a misnomer even though it is often used in connection with pulp-mill retention aids and mine tailing clarifiers. The copolymer of acrylamide and an acrylate is anionic whereas a different choice of copolymer makes possible production of a cationic dispersant.

A goodly number of the chemical multinationals have developed these PAM water-soluble polymers. And since large-scale manufacture is not as critical in the case of the polymer as it is with acrylamide monomer, production plants are located in most industrialized countries.

Many patents cover the polymerization of acrylamide and comonomers. In most cases they call for the thermal polymerization of acrylamide (without or without an acrylate or another co-reactant) in an oil medium. Surfactants (and possibly a chelating agent) are incorporated to facilitate the emulsifying action of the polymer. The ratio of monomers to oil is probably 3:2.

Polyacrylates, based on the polymerization of acrylic acid with or without methacrylic acid, can also be of varying molecular weights.

The acrylic acid suppliers dominate the commodity end-uses (coating and adhesive emulsions, etc.) but a number of independent companies concentrate on converting acrylic acid to latex thickeners, textile sizes and soil conditioners.

Acrylic acid can be polymerized as a homopolymer, copolymerized with methyl methacrylate or converted via a precipitation process to sodium polyacrylate. The common element in these polymers is the active vinyl group but the degree of polymerization dictates most of the physical properties.

There a plethora of proprietary types of acrylic acid polymers although generally they can be grouped as polyacrylics, methacrylic/acrylic copolymers or sodium polyacrylates. The latter requires a more complex process because of the need to introduce the sodium ion via a precipitation step.

3.11.2 Alberta's strengths

There is a substantial and growing demand for water-soluble polymers in oil-drilling muds and in industrial water treatment in western Canada. Most mining operations utilize these polymers for flocculation and dewatering.

The same polymers have potential in enhanced oil recovery, several tests having demonstrated their efficacy in this application. Alberta's large reserves of heavy oils suggests that when EOR is a commercial reality, the province will be a very large consumer of water-soluble polymers.

Ammonia costs in Alberta are an inducement to manufacture acrylonitrile in the province. The necessary propylene for acrylonitrile manufacture can be separated from cat cracker streams in three large Edmonton-area refineries, segregated from the C3 cut from the Joffre ethane crackers or secured by the dehydrogenation of field propane. The same propylene could serve as a feedstock for manufacture of acrylic acid and its esters.

3.11.3 Supply/demand balance

Canadian imports of PAM totalled 4,058 tonne in 1981 and 3,595 tonne in the following year. Production of PAM in the United States under 35 kt in 1981 and probably has increased since then despite the recession. About 50 percent of the total went into water and wastewater treatment, another 30 percent into enhanced oil recovery and the balance into industrial process aids.

Demand for polyacrylamides has increased rapidly in the past few years, but much of the growth could be attributed to the emergence of various enhanced-oil-recovery projects in the States. Continued expansion of the market could be forecast if it were not for the collapse of crude oil pricing. Without more EOR activity, consumption (linked to water treatment applications) would probably not expand at much more than 5 percent per annum.

The proliferation of suppliers with clones of the specialized grades of water-soluble polymers should have a depressing effect on price if demand were to stagnate. In other words, the cost of acrylamide, already the largest element in the overall polymer price, could become of even increasing importance.

Unlike the large-volume esters of acrylic acid which depend so much on the coatings industry for their growth, the acrylic acid modified polymers are finding widening application as thickeners and modifiers in a host of different industries. They are displacing other materials (including the cellulosic ethers) as the cost differential swings in their favor. Acrylic acid is in long supply and increasingly becoming more cost effective as the producers switch to propylene as the major feedstock.

3.11.4 Major suppliers

Alchem Ltd., owned jointly by C-I-L and Nalco Chemical, polymerizes acrylamide at Burlington and does formulating in Alberta. Nalco Chemical makes its PAM at Garyville, Louisiana.

Alkaril Chemicals already manufactures water-soluble polymers in Mississauga, Ontario.

Allied Colloids is a diversified producer of water-soluble polymers in the United Kingdom, has a PAM unit in Marietta, Ga for the textile industry and has a marketing position in western Canada.

Baker International's Magna group in Houston, TX makes polyacrylates for flocculants as well as scale inhibition.

Betz Laboratories makes PAM in Trevose, Pa and is especially active in Canada's pulp and paper industry.

Cyanamid Canada markets PAM grades made by parent American Cyanamid at Fortier, La; Kalamazoo, Mich; Linden, NJ and Longview, Washington. American Cyanamid makes acrylamide as well.

Dearborn Chemical, the Chemed subsidiary, makes polyacrylates at Lake Zurich, Ill (mostly as a scale inhibitor) and does formulating in Alberta.

Diachem Industries has begun making liquid PAM in Vancouver, Thunder Bay and Trois-Rivieres.

Diamond Shamrock makes polyacrylates for thickening applications at Cedartown, Georgia.

Dow Chemical is a PAM producer at Midland, Michigan.

BF Goodrich Canada has developed a growing business in Alberta's oilpatch for the polyacrylates its parent makes at Avon Lake, Ohio.

Hercules makes its polyacrylamide at Hopewell, Va.

Merck's Calgon division makes PAM at Elwood City, Pennsylvania.

Rohm & Haas, a major in acrylates, makes polyacrylates in Bristol, Pa and in Philadelphia for thickening and flocculating purposes.

Union Oil of California makes Polyhall PAM grades at Charlotte, North Carolina.

3.12.0 Polyvinyl alcohol and derivatives

Vinyl acetate, though sold primarily for use in vinyl emulsions, is also the starting point for the manufacture of polyvinyl alcohol and its derivatives.

Polyvinyl alcohol (PVOH) is one of those polymers on the borderline between a commodity and specialty classification. Its relatively high price (in the $2,000-2,500 per tonne range) and multiplicity of grades belies the fact that it is produced in very large tonnages world-wide. A key cost element: the price of vinyl acetate monomer and an ability to find a home for byproduct acetic acid.

3.12.1 The manufactured products

PVOH is a white granular powder and its aqueous solution is coloress and clear. It is a unique material because it can be plasticized by water. (Solubility depends on the degree of polymerization and hydrolysis.)

Though the supply of vinyl acetate monomer is critical in the manufacture of PVOH, production plants are not necessarily tied in with VAM operations. PVOH producers exist world-wide, in Third World countries (Brazil, Venezuela, India, etc.) as well in the major industrialized nations.

PVOH cannot be prepared by direct polymerization since the monomer vinyl alcohol is essentially an unknown compound. Commercially, the polymer is produced from polyvinyl acetate (PVA) by controlled hydrolysis. The PVA is reacted with an alcohol, replacing the acetyl group with hydroxyl groups to yield the PVOH. The hydrolysis of the acetate groups can easily be accomplished through ester interchange with methanol in the presence of anhydrous sodium methylate or aqueous sodium hydroxide. It is estimated that in the U.S.A. about 70 percent of all PVOH consists of fully hydrolyzed types. Acetic acid and methanol can be recovered or ethyl and/or methyl acetate byproduct has been sold in the merchant market.

Partially-hydrolyzed polyvinyl alcohol is a protective colloid widely employed in vinyl emulsions.

Fully-hydrolyzed polyvinyl alcohol makes an excellent sizing material in textiles and paper.

Polyvinyl butyral is plasticized to produce a soft, pliable sheeting as an interlayer in safety glass, implosion shields, etc.

Polyvinyl formal, formed by reacting the polyvinyl alcohol (PVAL) with formaldehyde, has a longstanding application in wire enamels and electrical insulation.

PVA fibers are extruded in Japan for use in various textile applications.

Ethylene vinyl alcohol (EVAL) coextrusions is an extension of the film water-soluble film technology of several years ago. The EVAL is exceptional barrier properties that should be useful in flexible film constructions and in plastic bottles.

POLYVINYL ALCOHOL AND DERIVATIVES

Base chemicals　　　First-step intermediates

[Acetic acid]*+[Ethylene]*---->[Vinyl acetate]*

Intermediates　　　Specialty products

[Vinyl acetate]--------------> [Polyvinyl acetate]

[Polyvinyl acetate]----------> [Polyvinyl alcohol]

[PVOH]+[Ethylene]*-----------> [Ethylene vinyl alcohol resin]

[PVOH]+[Formaldehyde]*-------> [Polyvinyl formal]

[PVOH]+[Butyraldehyde]-------> [Polyvinyl butyral]

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* already manufactured in Alberta

3.12.2 Alberta's strengths

Vinyl acetate, the monomer, is manufactured in Edmonton and a much larger VAM plant has been proposed for the same location. Much of the output is earmarked for Japan, where some of the most advanced technology and product development in polyvinyl alcohol exists. Methanol is available in the Edmonton area for the hydrolyzing step and the formaldehyde, also manufactured locally, could be used if the PVF resin were made.

The VAM plant would be able to absorb the byproduct acetic acid from a polyvinyl alcohol facility. (Only one integrated VAM/PVOH operation exists in North America today.)

Steam, which represents perhaps a sixth of the total polymer production cost, would be available at an Alberta site on the basis of burning relatively low-priced natural gas.

All polyvinyl alcohol and derivatives consumed in Canada must be imported. The PVOH resin purchases alone have totalled about 4,000 tonne with about 70 percent imported from offshore suppliers (in Japan, Taiwan, Britain, West Germany). The adhesives industry in the United States has been importing on average 10,000 tonne/year of PVOH from Japan and Taiwan.

No polyvinyl alcohol fibers are manufactured in the U.S. which could allow a Canadian producer using say, Japanese technology, to go after textile business south of the border. No aromatics are involved in the manufacture of these fibers so that the tariff barrier should be less of a problem than with polyesters and nylons.

Ethylene/vinyl alcohol conomomer film barriers are gaining recognition in the packaging industry (coextruded bottles, flexible-film laminates, etc.).

3.12.3 Supply/demand balance

An estimated 4,000 tonne of PVOH is consumed in Canada with all but a few hundred tonne imported. About 2,500 tonne of the total demand is for textile warp sizing. Usage of PVOH for textile warp sizing is probably around 50 kt/year in the States. This application is expected to grow at an average rate of 4 percent per year from 1982 to 1987 though little further replacement of starch and CMC by PVOH is expected. Another 50 kt of PVOH, primarily partially hydrolyzed PVOH, ends up in adhesives and emulsifiers. Growth in this sector is also slated to be at a 5 percent annual rate. In paper size and coating, a 20-kt/year market, the rate will probably be about 3 percent.

About half of Monsanto's Springfield capacity is dedicated to the manufacture of polyvinyl butyral and overall, perhaps 12 or 13 kt of PVOH is consumed in making the acetal. With formaldehyde the PVOH yields polyvinyl formal.

The use of PVOH in soluble films never caught on in the States. Neither has the fiber been accepted as an alternative to polyester fibers as it has in Japan. PVOH film from Japan has been gaining attention as a gas barrier layer in coextrusions.

In the United States, the PVOH output was at only 63 percent of capacity during 1982. If growth is at 4 percent per year as expected, 1987 production in the U.S. would still be well below the ability of Du Pont and Air Products to supply the product. Their recent expansions are interpreted as being motivated by the need for cost savings rather than by an attempt to keep ahead of market demand.

3.12.4 Major suppliers

Air Products & Chemicals sells its Vinol line in Canada.

Borden Chemical, a large-scale buyer of PVOH for its vinyl emulsion business, once manufactured polyvinyl alcohol. The company has a plant site in the Edmonton area.

Celanese Canada is the VAM producer in Canada and is its parent is also a partner in the Dutch PVOH plant at Europort.

Denka Kagaka Kogyo makes up to 30 kt/year of PVOH at Ohmi in Japan.

Hoechst makes as much as 25 kt/year of PVOH at Frankfurt in West Germany.

Japan Synthetic Chemicals has three Japanese plants with a combined capacity of over 60 kt/year.

Kuraray Rayon of Japan has plants in Nakajo (47 kt/year), Okayama (54) and Toyama (23.5 kt).

Monsanto makes 22.5 kt/year of PVOH and derivatives at Springfield, Mass, the company having built on the technology originally developed by Shawinigan Chemical.

Rhone-Poulenc has two PVOH units in France.

Unitika Chemical of Sakai in Japan can produce as much as 24 kt/year of PVOH.

3.13.0 Specialized styrenic products

It is difficult to draw the line between commodity and specialty grades of styrene polymers. Without question the homopolymer (crystal) and polybutadiene-modified types serving the injection molders and extruders are large-volume products with minimal grade differential. There are, however, more specialized uses of styrene as a monomer.

3.13.1 The manufactured products

Styrene-butadiene latices can be carboxylated or otherwise modified for use in carpet-backing, paper sizing and coal encrustation, among others.

Styrene-butadience latices are copolymers of butadiene and styrene in proportions that vary with the end-use. On average, however, the macromolecule contains about 40 to 50 percent styrene. Most SB latex is carboxylated for use in the carpetbacking industry. The latex is sold as a 50 percent dispersion in water.

The reaction of butadiene and styrene can be carried out on a continuous or batch basis. It is an emulsion polymerization technique so that a surfactant as well as a catalyst is essential to the process.

Styrene-butadiene block copolymer elastomers are a relatively new family of thermoplastic elastomers.

Styrene block copolymers incorporate elastomeric (polyisoprene, polybutadiene, ethylene-propylene) regimes that contribute to flexbility and toughness to the macromolecule. Typically, they are blended with commodity thermoplastics to improve performance in vital areas.

Styrene-maleic copolymers have higher heat resistance than do the more widely used styrene copolymer and ABS terpolymer grades. When maleic anhydride is the comonomer with styrene, the polymer is characterized by improved heat resistance and is therefore selected where a high heat deflection temperature rather than toughness is the critical property.

ABS terpolymers are the "low end" of the engineering resins classification and have enough grade differential to qualify as specialty materials.

ABS is generally regarded as a three-monomer (or terpolymer) system in which acrylonitrile (for heat stability, chemical resistance and aging properties), butadiene (for toughness) and styrene (for gloss, rigidity and processability) are combined in varying ratios. A fourth monomer such as alpha-methylstryene or methyl methacrylate can be introduced where desirable.

Relatively new is olefin-modified styrene-acrylonitrile (OSA), which is sold by Uniroyal as 'Rovel' and involves the combination of a saturated olefinic elastomer with US absorbers and anitoxidants in a styrene-acrylontrile matrix.

Straight styrene-acrylonitrile (SAN) copolymers have a market niche because they possess the gloss and clarity of polystyrene with added chemical resistance, high heat deflection temperature, toughness and loadbearing characteristics.

The ABS polymer is in fact composed of discrete rubber particles (based on butadiene) grafted with styrene-acrylonitrile (SAN) copolymer dispersed in a continuous matrix of SAN. In order to build in better heat and UV degradation resistance into ABS terpolymers, Borg-Warner, Monsanto and others incorporate some alpha-methyl styrene in place of the straight styrene monomer. The substituted styrene is comparatively low cost (it is a byproduct) in long supply but has slow reactivity in contrast to stryene.

Expandable polystyrene beads require addition of blowing agent (pentane) so that they can be used for making of drinking cups, packaging shapes and thermal insulation.

Expandable polystryene (EPS) is produced by a suspension-type polyermization process in which pentane or some other volatile organic blowing agent is present. The impregnation of the polymerized beads with the blowing agent may also be carried out in a secondary operation.

The technology to extrude crystal into foam sheet -- especially for thermal insulation purposes -- is closely held so that a multiplicity of plants exist. There are more producers of EPS beads than there are of Dow's Styrofoam or its equivalent and there is also a trend to regionalization is this area.

In the suspension process for EPS, polymerization is carried out in an aqueous medium to permit removal of the exotherm of the reaction. The final product from a suspension process is in the form of small spherical beads. (Mass polymerization yields a crystal in pelletized form.)

Ion-exchange resins of the anionic and cationic types are copolymers of styrene and divinylbenzene (a styrene homologue).

STYRENE SPECIALTY POLYMERS

Base chemicals	First-step intermediates
[Ethane]*	[Butadiene]
[Ethylene]*+[Benzene]*	[Styrene]*
[Propylene]+[Ammonia]*	[Acrylonitrile]
[Propylene]+[Benzene]*	[alpha-Methyl styrene]
[Butane]*	[Maleic anhydride]

Intermediates	Specialty products
[Styrene]+[Butadiene]	[Block copolymer elastomers]
[Styrene]+[Butadiene]	[SB latices]
[Styrene]+[Acrylonitrile]	[SAN resins]
[SAN]+[a-Methylstyrene]+[Butadiene rubber]	[ABS terpolymers]
[Styrene]+[Maleic anhydride]	[Styrene-maleic copolymers]
[Styrene]+[Pentane]	[Expandable polystyrene beads]
[Styrene]	[Polystyrene crystal]

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* already manufactured in Alberta

3.13.2 Alberta's strengths

A world-scale (300 kt/year) styrene monomer plant will be operating at Scotford by the middle of 1984. The price of this styrene monomer will be determined, to a large degree, by the fact that much of that styrene must be competitive in the Japanese market.

Though no butadiene is yet recovered from the debutanizer units at Joffre, extraction of the diolefin awaits a sizeable outlet in the province. The C4 fraction from the ethylene plants could be augmented by utilizing some propane with the ethane in the feed. The eventual production of cumene-based phenol in Alberta would provide a product alpha-methylstyrene source.

Because a C4 cut from the Joffre crackers is moved by train to Sarnia, butadiene could presumably be loaded in otherwise empty tankcars on the return trips. Thereby, an Alberta styrenic resin or latex producer could be provided with a butadiene supply not too different in cost to what applies in the Sarnia area.

There is at present no production of specialty styrenics in the western half of North America.

Consumption of specialty styrenics is being advanced by the trend to the "alloying" or blending of various polymers for the best performance/cost ratio in a specific application.

3.13.3 Supply/demand balance

There is considerable excess capacity in ABS, which is one reason that the number of players in the business dropped to three in North America. Virtually all the capacity is, however, centered in the eastern half of the continent despite the Silicon Valley phenomenon on the west coast and the prospect of more automobiles being assembled in California.

The polystyrene producers were understandably in the doldrums since 1979: there has been no market growth since then. A negative rate is presumably not in the cards for the next year. In fact, the industry projects increases in demand in 1984 of about 5 or 6 percent and a 3 to 5 percent rate beyond that year.

Price weakness was the inevitable result of the overbuilding that occurred in the 1970's. Profit margins were squeezed unmercifully by the rise in the cost of styrene monomer in the same period. Foams promise to do somewhat better than solid forms of polystyrene but it is evident that there is more than enough EPS bead capacity to satisfy at least the eastern half of the continent.

The latex industry has been going through a levelling off of demand for textile carpeting. The high-solids foaming latex was particularly hard hit by the recession and the trend towards using fillers to impart fire retardancy to the backing. A return by the consumer to separate rug underlay reduced the demand for integrated backings.

3.13.4 Major suppliers

Arco Polymers manufactures its Dylite EPS foam and Dylark styrene-maleic copolymers in Pennsylvania. Arco once commanded the EPS cup-bead market in Canada.

BASF Canada produces Styropor EPS at Laval, Quebec. BASF Wyandotte makes EPS at South Brunswick, New Jersey.

Borg-Warner Chemical is one of Canada's two ABS terpolymer producers and the industry leader in the United States.

Dow Chemical extrudes Styrofoam at Fort Saskatchewan and is a producer of polystyrene and SB latices in Sarnia (and additional latex at Varennes, Quebec). In the U.S.A., Dow makes ABS terpolymers and ion-exchange resins (the latter at Midland, Michigan).

Monsanto Canada makes its ABS terpolymers in Montreal. The company is also one of world's leading producers of maleic anhydride and a producer of styrene-maleic-butadiene terpolymers and styrene-acrylonitrile (SAN) copolymers.

Polysar is Canada's other large producer of styrene-butadiene latices (at Sarnia) and the operator of two polystyrene resin plants (at Cambridge, Ont. and Pointe-aux-Trembles, Que).

Rohm & Haas is, along with Dow Chemical, a pioneer in ion-exchange resins.

Shell Canada is operating a styrene monomer plant at Scotford. It has polystyrene process technology and is the leading supplier of the Kraton thermoplastic elastomers.

3.14.0 Hydrocarbon resins

Hydrocarbon resinformers and dicyclopentadiene are extracted from the bottoms of the debutanizer in ethylene plants. They are subsequently polymerized to the range of hydrocarbon resins employed in the rubber, adhesives, paint, ink and concrete industries. The C5+ stream from the Joffre ethane crackers is currently being shipped to the U.S. Gulf Coast. The volume of the C5+ stream will rise to 45 kilotonne/year (of which 25 percent or 10 kt/year will be resinformers) when AGE II is operational.

3.14.1 The manufactured products

The AGE C5+ stream can produce aromatics (BTX) and **resinformers** in the initial cut. A resinformer extraction step could obtain **dicyclopentadiene** (DCPD) that was commercially pure. This stream from the two ethylene plants will contain up to 15 ktonne of resinformers.

DCPD is used in the production of pesticides , as an additive for hydrocarbon resin manufacture, in unsaturated polyesters, in EPDM rubbers, and in making fire retardents, epoxy curing agents, alkyd resins and bodied oils. By not refining the raw material as carefully a CPD/DCPD concentrate can be produced for hydrocarbon resin manufacture only.

Simple distillation or vacuum distillation is used to extract the resinformers from the C5 bottoms stream from the ethylene plant.

Hydrocarbon resins are made from polymerizing the unsaturated component of a C5 to C8 cut and producing a flaked solid or emulsion product. The resin markets are the rubber, vinyl flooring, adhesive, paint, concrete curing compound and some industrial product areas. More specialized markets include printing inks, bubble gum, and coatings.

Production of resins involves polymerizing the resinformer with a catalyst or using heat and pressure into a semi-solid to solid material. Usually the extraction of the resinformers and the making of the resins are done at different locations. The C5 resinformers that come from gas-based ethylene crackers are almost always made into hydrocarbon resins at another site.

HYDROCARBON RESINFORMERS, DERIVATIVES

Base chemicals		First-step intermediates
Ethane-cracker pyrolysis gasoline*	----->	Non-aromatic fraction

Intermediates		Specialty products
Non-aromatic fraction	----->	Resinformers
Non-aromatic fraction	----->	Dicyclopentadiene
Resinformers	-------------->	Hydrocarbon resins

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* already manufactured in Alberta

3.14.2 Alberta's strengths

The current netback on the C5+ stream must be very low. (If the hydrocarbon resinformers are not cut out of the stream, the stream is normally hydrogenated for use in the gasoline pool of a refinery on the Gulf Coast.) Thus the cost of the raw material for DCPD and hydrocarbon resinformer manufacture in Alberta should be below the norm for North America.

About half the C5+ stream is benzene. Benzene would have an established value in the local market if the stream upgraded in Alberta.

The basic resinformer business has the flexibility to produce either resinformer or dicyclopentadiene depending on markets. Potentially pesticide manufacture could provide some local market for DCPD.

The sole Canadian producer of hydrocarbon resins (in Ontario) imports its resinformers from the U.S. Gulf Coast. The company would constitute a 4 kt/year outlet for an Alberta supplier.

The production of hydrocarbon resins themselves would be based on integration of DCPD/resinformer extraction with the finishing step. Good raw material costs could make a resin plant competitive across the western half of North America and perhaps into export markets. The French and Koreans have consistently moved product into North America.

3.14.3 Supply/demand balance

DCPD and DCPD resinformers are supplied in North America by four producers and volume amounts to about 45 kilotonne. DCPD capacity runs to an estimated 52 kilotonne at present.

Outlook for DCPD is for fairly tight supply situation as ethylene crackers on the Gulf Coast are switched from naphtha to gas liquids and older units are shut down.

Capacities of the producers of dicyclopentadiene and C5 resinformers in 1981 were as follows:

	kilotonne
Chemical Exchange, Houston, TX	14
Dow Chemical,Freeport, TX	9
Exxon Chemical, Baton Rouge, LA	20
Conoco, Chocolate Bayou, TX	9
Total	52

Annual DCPD demand in Canada is probably no more than 500 tonne in the rubber and miscellaneous industrial areas. St. Lawrence Resin Products yearly imports 2 to 4 kilotonne of resinformers of the DCPD type for its operations.

In the U.S., demand for DCPD and its resinformer derivatives breaks down as follows:

	kilotonne
Hydrocarbon resins	40
Unsaturated polyesters	20
Rubber (EPDM)	15
Pesticides	5
Miscellaneous	20

From a manufacturing and market point of view Alberta could have a North American scale plant to extract DCPD and resinformers in Alberta.

The production of hydrocarbon resins in the province could be a second step that is contingent on resinformers being extracted in the province.

Imports of all hydrocarbon resins come into Canada from United States, France, Korea and sometimes from Italy at volumes of $12 million annually. St. Lawrence Resins produces some $4 to $5 million worth of product as well, making the Canadian market about $17 million.

Major hydrocarbon resin producers in the U.S. include Exxon Chemicals, Neville Chemical, Lawter Chemicals, Reichhold Chemical, Zeigler and one or two other small plants.

The supply of hydrocarbon resins in North America and internationally exceeds demand. American producers have tended to export a reasonable amount of their production, particularly the more refined grades, to Canada and other developed countries.

In Canada imports are about twice the volume of resins produced in the country, which does open up opportunities for import replacement. Key to such a move is feedstock availability.

Estimated current demand:

Canada	16 kilotonne
U.S.A.	150 kilotonne
Global	300 - 450 kilotonne

The growth in the market for hydrocarbon resins is 2 to 3 percent annually. The applications tend to be mature, but stable with only hot melt adhesives and some concrete curing materials as new and growing uses for hydrocarbon resins.

3.14.4 Major suppliers

Exxon Chemical sells C9-type hydrocarbon resins based on the output of a facility purchased from Hercules.

Hercules has been in the hydrocarbon resin business and retains technical expertise.

Neville Chemical is very strong in the U.S. market because of its start with coumarone-indene and other coal-derived resins.

St. Lawrence Resin Products is the Ontario producer that is buying resinformers from Texas.

3.15.0 Sulfur compounds

Adding value to elemental sulfur is often the outcome of combining sulfur with organic materials and synthesizing several of a wide range of thio derivatives. There are, however, some inorganic sulfur compounds that qualify has reasonably specialized products and accordingly, command a higher price.

3.15.1 The manufactured products

Xanthates, salts obtained by reacting an alkali, carbon disulfide (CS2) and an alcohol (usually ethanol, isopropanol, one of the various butanols or amyl alcohol), are the most commonly used froth flotation collectors in ore dressing. Alternatives to xanthates in mining include **dialkyl thiocarbamates** and **dithiophosphates**, also sulfur compounds albeit more complex in nature.

The alkali metal salts of xanthic acids are relatively stable solids, pale yellow when pure, with a disagreeable odor.

Xanthates prepared in solid form can move long distances to market -- as is evident from the appearance of substantial tonnages of European material at North American mining locations. Liquid formulations, which may contain as much as 75 percent water, aren't nearly as transportable.

The alkali metal xanthates are generally prepared by the reaction of flake sodium or potassium hydroxide with an alcohol to form an alkoxide which is then reacted with carbon disulfide.

Reacting an alcohol with hydrogen sulfide rather than with CS2 results in a mercaptan. **Methyl mercaptan** is the precursor for **methionine** as well as one of the triazine herbicides. **Ethyl mercaptan** is a raw material for a couple of important insecticides (Thimet and Disyston) and for the pre-emergent herbicide, Eptam. It is also an odorant in natural-gas and petroleum refinery streams. The **n-propyl mercaptan** is an intermediate for cotton defoliants and **propargyl mercaptan** is used in making the Avadex herbicide.

Hydrogen sulfide generated in a carbon disulfide plant is often converted to **sodium hydrosulfide**, a reducing agent in the dyestuffs industry but also a promising froth flotation reagent.

Sodium hydrosulfite deserves attention because it has growing use as a brightening agent in thermomechanical pulping. In certain other applications it competes with **sodium sulfite.** However, in the western half of the continent the most promising market for sodium sulfite is in wood pulping and, to a lesser extent, boiler-water treatment.

Sodium hydrosulfite, otherwise known as sodium dithionite or sodium sulfoxylate, is available as a crystalline powder. It is very soluble in water and is often sold in a refrigerated aqueous solution.

The supply of sodium hydrosulfite has risen sharply in recent years as the paper industry vies with the textile mills for a source of this bleaching agent. At one time zinc hydrosulfite, a much cheaper reducing agent for mechnical pulps, was the norm in the newsprint mill. Zinc, however, was identifed as a bad actor in pulp-mill effluents.

Currently the most accepted process for making merchant hydrosulfite (as distinct from the Borol route to in-situ brightening agent) is the use of sodium formate as a reducing agent in combination with sulfur dioxide and caustic soda. The chief advantage of this process is that it uses the sodium formate from a pentaerythritol plant that would otherwise be destroyed and discarded as waste. In addition, this process produces anhydrous sodium hydrosulfide and has a lower metal content than product made by alternate processes.

A second process utilizes the zinc reduction at room temperature of sodium bisulfite to yield zinc sulfite and sodium hydrosulfite. The mixture is treated with milk of lime to lower the solubility of zinc sulfite which is removed by filtration. Sodium chloride is added to precipitate sodium hydrosulte.

If the manufacturer wants only solution, he has the choice of a third process that involves the reducing of a sodium sulfite solution with sodium amalgam at a controlled pH in the range of 5 to 7.

SPECIALTY SULFUR COMPOUNDS

Base chemicals First-step intermediates

[Sulfur]*------------------>[Sulfur dioxide]

[Methane]*+[Sulfur]*-------> [Carbon disulfide]

[Hydrogen]*+[Sulfur]*------> [Hydrogen sulfide]*

Intermediates Specialty products

[SO_2]+[Sodium formate]*-------> [Sodium hydrosulfite]

[CS_2]*+[Ethylenediamine]-------> [Ethylene bisdithiocarbamates]

[CS_2]*+[Alcohol]+[NaOH/KOH]------>[Xanthates]

[H_2S]*+[Methanol]---------------> [Methyl mercaptan]

[Methyl mercaptan]+[HCN]--------> [Methionine]

[H_2S]+ [Ethanol]------------>[Ethyl mercaptan]

[Ethyl mercaptan]----------->[Triazine herbicides]

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* already manufactured in Alberta

3.15.2 Alberta's strengths

Carbon disulfide manufacturing costs in Alberta benefit from the province's excellent position with respect to both natural gas and sulfur. Hydrogen sulfide is also available at a relatively low cost.

Sulfur burners for hydrosulfite and sulfite production operate in several parts of the province as part of very large sulfuric acid plants associated with phosphatic fertilizer operations.

Sodium formate, an intermediate in the manufacture of sodium hydrosulfite, is currently being destroyed in the manufacture of acetic acid at Clover Bar.

Domestic demand for sodium hydrosulfite -- primarily for groundwood brightening -- should exceed 15,000 tonne per annum by the end of the decade. Consumption of the hydrosulfite in the Pacific northwest should also increase with the trend away from chemical pulping in favor of the chemothermomechanical processes.

Imports of sodium sulfite average 6,000 tonne per year with a large portion originating in Japan, the U.K. and West Germany. So, there is some tonnage of offshore material to displace in the domestic market.

The different flotation collectors are employed in many metal mining operations in both western Canada and the western states of the United States. Perhaps 4,000 tonne of xanthates can be consumed annually in western Canadian mines.

Competition from other North American xanthate producers has been lessened in recent years by the closure of a California plant as well as two in western Canada. A large portion of the dialkyl thianocarbamates and dithiophosphates supplied to the western U.S. mining operates is currently made in Baltimore, Maryland.

3.15.3 Supply/demand balance

In Canada the dominant application for sodium hydrosulfite is in the pulp and paper mills devoted to mechanical pulping. In 1981 the pulp mills purchased an estimated 9.3 kt whereas the cotton industry took no more than 1.3 kt in that year. It is estimated that U.S. demand for sodium hydrosulfite will reach 25 kt in either 1983 or 1984. About a third of that demand originates in the textile mills. Another 30 percent goes into wood pulp brightening and 15 percent into clay bleaching. The miscellaneous applications include the stripping of dyes from fabrics, as well as the bleaching of straw, soap and some sugars. It is forecasted that sodium hydrosulfite demand for pulp bleaching will grow by between 8 and 10 percent for the next several years -- the outgrowth of the accelerating acceptance of TMP pulping.

Canadian imports of xanthates totalled 2,455 tonne in 1981 with Belgium the largest source. Over half those imports were grades of potassium amyl xanthate (PAX) and most of the balance was sodium isopropyl xanthate (SIPX). Much of the PAX is destined for British Columbia.

The U.S. Bureau of Mines reports that in 1980 the consumption of PAX in froth flotation was just under 1,000 tonne. Another 850 tonne of sodium ethyl xanthate were consumed and usage of SIPX exceeded 500 tonne. Therefore the U.S. market for xanthates would appear to be no more than 3,000 tonne/year, whereas during the 1970's it was perhaps triple that size. The drastic decline in the world copper price has made it impossible to continue mining the large chalcopyrite deposits in the American southwest.

The closure of three xanthates plants in North America has removed whatever surplus capacity there was in this product area. On the other hand, demand from xanthates as collectors has fallen off because of competition from other froth flotation reagents and also due to the sharp decline in the sulfide ore mining industry.

To add to the woes of the existing xanthates suppliers, the Belgian franc has been devalued by about 40 percent to a point where it is possible for UCB to undercut the North American producers at many mine locations. The German vendors are also in a better position to compete than they were a few years ago.

Canadian imports of mercaptans, 1,404 tonne in 1978 rising to 1,726 tonne in 1981, suggest a very modest domestic market for these thio compounds. The ethyl and t-butyl types sold by Pennwalt as natural gas deodorizers totalled not much more than 200 tonne in 1981. The t-dodecylmercaptan, made from propylene tetramer, is one of the chain-length distribution regulators in styrene-butadiene rubber manufacture. Canadian imports of that particular mercaptan are about 300 tonne per annum. Additional quantities are imported for the manufacture of specialized non-ionic surfactants. But the usage of mercaptans for pesticides (the largest markets for mercaptans in the U.S.) or the thioglycolates, etc. developed by Evans Chemetics (a division of W.R. Grace) etc., for a variety of applications doesn't exist in Canada.

3.15.4 Major suppliers

BASF makes both sodium sulfite and sodium hydrosulfite in West Germany and competes to some extent in the Canadian market.

C-I-L makes xanthates at Copper Cliff and once operated units at Edmonton (the old Celanese unit) and at Thompson, Manitoba. It is a partner with Stauffer in Cornwall Chemicals.

Celanese Canada is now associated with Virginia Chemicals, North America's largest manufacturer of sodium hydrosulfite.

Cyanamid Canada is a producer of xanthates at Niagara Falls.

Dow Chemical was once a supplier of xanthates out of Pittsburg, California.

Erco Industries, a major force in pulp bleaching chemicals (sodium chlorate), has access to hydrosulfite technology developed by an European affiliate.

Minerec of Tucson, Arizona has dialkylthionocarbamates, dithiophosphates and xanthates made for it by Essex Chemical in Baltimore, Maryland.

Pennwalt Corporation is one of the two American producers of the higher mercaptans.

Phillips Chemical also makes the various mercaptans from hydrogen sulfide removed from a refinery stream in Texas.

Stauffer Chemical is the largest single manufacturer of carbon disulfide in North America, a large buyer of mercaptans for its various pesticide intermediates and a producer of sodium hydrosulfide and of sodium sulfide.

Thio-Pet Chemicals is a producer of carbon disulfide at Fort Saskatchewan and also makes xanthates there.

3.16.0 Caustic potash and derivatives

Potassium hydroxide (KOH), manufactured via the electrolysis of potassium chloride, is a strong alkali with a wide range of industrial uses. No caustic potash production is carried out west of Sauget, Ill (Monsanto) despite the raw material (potash) originating in Saskatchewan or New Mexico. If sufficient demand can be identified for caustic potash, potassium carbonate, potassium phosphates, potassium soaps and other potassium chemicals in an area served competitively from an Alberta producing point -- or if more liquid fertilizers are used in the western part of North America -- an investment in facilities to make potassium derivatives can be justified.

3.16.1 The manufactured products

Potassium hydroxide can be produced by electrolysis from a solution of muriate of potash on a reasonably large scale (between 25 and 50 kilotonnes a year).

Potassium hydroxide (KOH) is more effective alkali than is less-expensive caustic soda. most is sold in 45 to 50 percent solutions with lesser tonnages concentrated to 61 percent KOH and cast into sticks or pellets. There is also a demand for 92 percent product, sold as flakes or pellets.

Potassium carbonate is a white, odorless, hygroscopic sold available in solution and dry forms (both hydrate and calcined).

Electrolytic production of KOH is analogous to that for caustic soda with potassium chloride substituted for sodium chloride. Chlorine is the coproduct so that commercial "sink" must be found for the chlorine within a reasonable shipping distance. Both mercury and diaphragm cells can be used to produce KOH but in practice producers select mercury cells to secure a product relatively free of the chloride ion. In the long term mercury cells will be superseded by the membrane type because mercury is subject to environmental restrictions.

Potassium carbonate and/or **potassium phosphates** would be the major derivatives, the carbonate being made by the reaction of the KOH with carbon dioxide, the phosphates by using either wet-process or thermal-grade phosphoric acid.

Potassium soaps would result from reacting the alkali with tallow and/or tall oil fatty acids.

Ammonium bicarbonate is grouped with the potassium salts because any move to produce potassium carbonate may be more attractive if the same equipment could be employed for the production of ammonium bicarbonate as well.

CAUSTIC POTASH AND DERIVATIVES

Base chemicals First-step intermediates

[Muriate of potash]-------->[Caustic potash (KOH)]

Intermediates Specialty products

[KOH]+[Carbon dioxide]*----------> [Potassium carbonate]

[KOH]+[Phosphoric acid]*-------> [Potassium phosphates]

[KOH]+[Carbon disulfide]*+[Amyl alcohol]---->[Potassium amyl xanthate]

[KOH]+[Fatty acids]---------------> [Potassium soaps]

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* already manufactured in Alberta

3.16.2 Alberta's strengths

Alberta is closer to the existing potash mines than are localities (Ontario, New York, Ohio, Illinois, Alabama, Delaware) in which KOH is currently being manufactured.

Electric power costs in Alberta are in most cases lower than in the above-mentioned localities. Some of the older KOH plants will close as power costs rise elsewhere.

A "sink" for the coproduct chlorine exists in a local petrochemical industry and in pulp-mill bleacheries to the west. The chlorine would also be available for the chlorination of hydrocarbons or the manufacture of phosgene, among others.

There is an existing local market of perhaps 2,000 tonne per year for caustic potash and potassium carbonate combined.

The Japanese potassium carbonate market (mostly for color TV glass) may be more accessible from Alberta than from the eastern U.S. plants.

Fertilizer suppliers selling potassium sulfate for soils which can not tolerate chloride ions would have the opportunity of buying a high-analysis fertilizer in the form of potassium phosphate.

Exxon's research on the use of potassium carbonate for catalytic coal gasification could redound to the advantage of a western producer.

Liquid potassium soaps could be made for a west-coast (California included) market if tallow and/or tall oil fatty acids were available at attractive costs.

There is no serious North American production of ammonium bicarbonate in spite of the stable, if not increasing, demand for the leavening agent in the manufacture of biscuits and other baked goods. Existing demand for ammonium bicarbonate is met by offshore imports. With ammonia and carbon dioxide costs well below those elsewhere in the world, it may be possible to ship ammonium bicarbonate to outlets in Pacific Rim countries.

Caustic potash and potassium carbonate are in oversupply in the States, although the Niagara Falls plant of Occidental Chemical has been closed. Diamond Shamrock is affiliated with a new producer, Korea Potassium Chemical in Inchon, that could preempt the Far East market for potassium carbonate.

The usage of tetrapotassium pyrophosphate (TKPP), the the potassium salt most widely sold as a builder in liquid detergents, is declining because of restrictions on the use of phosphates for laundry compositions.

3.16.3 Supply/demand balance

At best no more than 9 kt of KOH are consumed annually in Canada. Of that total close to 3.5 kt are imported. There being a rather small specialty glass industry in Canada, potcarb imports are minor. In 1981 they totalled 1,265 tonne.

The U.S. caustic potash market is in the neighborhood of 200 kt/year. Of that tonnage about 60 to 65 kt ends up in the manufacture of potassium carbonate and another 30 kt goes into potassium soaps. 20 to 25 kt goes into potassium phosphates and 20 kt into other potassium chemicals. Liquid fertilizers absorb between 20 and 25 kt.

Production of potassium carbonate in the U.S. has never exceeded 65 kt/year. Imports of color TV's have militated against expanded domestic potcarb consumption. Even so, glass producers south of the border consume about 22 kt of potcarb annually. Liquid soaps and cleaners account for another 6.5 kt of liquid potcarb with heavy duty cleaners gaining ground in the detergent industry. Potassium salts represent about 12 kt of demand with silicate being the major material. An estimated 8.5 kt are used as rubber antioxidants. Photographic and other miscellaneous applications, which entail shipping of liquid potcarb, consume about 6 or 7 kt.

With demand for caustic potash and potassium carbonate expected to growth no more than 3 percent per annum until some of the exotic applications for potcarb advance to the commercial stage, the need for new capacity will only come about if more companies retire from the field. Pennwalt took 27 kt/year of caustic potash out of production at Calvert City, KY in 1982 and the Occidental plant closure at Niagara lost the U.S. another 80 kt/year. Yet there is still an oversupply in North America despite the paucity of vendors.

3.16.4 Major suppliers

C-I-L already manufactures caustic potash in Canada and has a subsidiary (Inland Chemical) operating in Alberta. Also C-I-L participates in the phosphatic fertilizer business in eastern Canada and in the contiguous U.S. states.

Canadian Occidental is affiliated with Occidental Chemical, which has operated a KOH/potcarb plant at Niagara Falls. Occidental is also into phosphatic fertilizers.

Diamond Shamrock is North America's largest producer of both caustic potash and potassium carbonate. (The plant is at Muscle Shoals, Ala). The DSAG plant at Fort Saskatchewan is sitting on a salt deposit.

Dow Chemical makes no caustic potash south of the border but does have a chloralkali works at Fort Saskatchewan.

Erco Industries is a significant consumer of KOH for phosphate builders.

Monsanto is a caustic potash producer and a major in phosphate detergent builders.

3.17.0 Terpenes and other turpentine derivatives

Crude turpentine recovered from the sulfate (kraft) pulp mill process is refined by independent refiners into a number of terpene chemicals used as additives in industrial, household, food and pharmaceutical products. Depending on the tree species used in pulping and the processing technique, 65 to 80 percent of the crude turpentine is recovered in usable byproducts.

It has been estimated that up to 15 kilotonne of turpentine can be recovered annually from kraft pulp mills between the Pacific Coast and Espanola, Ontario. Turpentine, a mixture of unsaturated, bicyclic terpene hydrocarbons associated with the oleoresins occurring in coniferous trees, was once a widely used solvent in the coatings field. Over the years, an aroma chemicals industry has been developed based on upgrading the pinene contained in the crude turpentine.

3.17.1 The manufactured products

The major turpentine derivatives are pine oil used in cleaners and disinfectants, polyterpene resins used in pressure-sensitive and hot-melt adhesives, and a variety of chemically-modified terpene fractions used in insecticides and synthetic flavors and fragances in foods (including Vitamins A and E) and in perfumery preparations.

The individual kraft mills that bother to recover crude sulfate turpentine do a rough steam stripping of the liquid to remove low-boilers such as the sulfur compounds. Then the stabilized turpentine is shipped to one of several U.S. companies employing distillation to segregate the alpha-pinene and beta-pinene isomers and to remove the high-boiling constituents.

The **beta-pinene** is the more valuable fraction because it is the precursor for the production of **myrcene, geraniol** and **citronellol.** The mixed pinenes have a role in the production of **3,7-dimethyl-1,6-octadiene** and in **linalool.** These same mixed pinenes or any surplus alpha-pinene can also be sold as **pine oil.**

The crude turpentine is usually recovered from condensed pulp digester gases and it can be obtained from skimmings from the black pulp "mother liquor" at a later stage.

The three successive steps in crude turpentine refining are distillation, fractionation and chemical conversion. Distillation of the crude in a distillation column at about 180 C. separates the non-terpene low boiling components and bottoms, representing 20 to 35 percent waste material. Northern tree species produce greater volumes of waste than southern species.

The distilled terpene is then subjected to fractional distillation to isolate the terpene fractions, dominantly alpha-pinene (between 60 and 70 percent, depending on tree species) and beta-pinene (20 to 25 percent). The unfractionated mix, when de-sulfurized, is suitable for use as a solvent (paint thinner), though this route is seldom followed when alternative higher-value uses are possible.

The terpene fractions undergo a variety of chemical conversion processes for produce desired and products, ranging from simple one-step treatment to obtain, for example pine oil, to multi-stage catalytic conversion -- often using several different terpene fractions -- to produce, for example, a chemical substance like pseudoionone, which is used in the manufacture of Vitamin A.

TURPENTINE AND ITS DERIVATIVES

Base chemicals First-step intermediates

Crude turpentine*--------> Turpentine solvents

Crude turpentine--------> a-Pinene + b-Pinene

Intermediates Specialty products

a-Pinene----------------> Pine oil

a-Pinene----------------> Dipentene --> Adhesive resins

b-Pinene----------------> Polyterpene resins

b-Pinene----------------> Flavor & fragrance chemicals

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* already manufactured in Alberta

3.17.2 Alberta's strengths

Alberta represents a reasonably central turpentine collection point for the pulp mills stretched from Vancouver Island to the Sudbury area.

Thermal energy for the distillation steps should be secured in Alberta at about the best price possible in North America.

Western Canadian consumers could probably absorb about 1,500 tonne of turpentine annually in the form of pine-oil disinfectants (e.g. "Pine-Sol").

Another 500 tonne/year of pine oil can be sold as flotation frother in British Columbia. It is also possible that pine oil could compete as a frother in potash and coal flotation.

An international market exists for terpenes, be they mixed isomers or the isolated beta-pinene. No single company dominates the flavors and fragrance business; International Flavors & Fragrances and Givaudan between them have less than 20 percent of the market.

Several U.S. turpentine refiners compete for available crude. SCM Corp and Union Camp, both in Jacksonville, Fla, purchase Canadian turpentine as does Northwest Petrochemical in Anacortes, Wash and Reichhold in Pensacola, Florida. Hercules is also a fractionator.

There is no duty on the crude turpentine crossing the U.S. border but a 5 percent ad valorem charge is applied to pine oil and other upgraded products.

Demand for turpentine as a solvent and pine oil as a disinfectant-solvent is restrained by the price volatility of these materials.

New technology on the horizon may reduce the dependence of citronellol producers on beta-pinene.

3.17.3 Supply/demand balance

The most recent U.S. data on the consumption of crude turpentine indicate that over 100 kt are utilized annually with exports adding another 5 kt to the total. While southern U.S. tree species yield 20 to 25 percent b-pinene, northern and northwestern species yield only 3 to 11 percent. To make matters worse, the northern trees contain as much as 20 percent of terpene fractions for which no commercial use has been found. Southern species have less than 5 percent of such superfluous terpenes. Gum turpentine has up to 35 percent b-pinene while wood turpentine has a maximum of 2 percent.

The scarcity of b-pinene is such that one major fractionator, SCM, found it worthwhile to isomerize a-pinene fractions to b-pinene. SCM abandoned this route in 1982, when it opened a new plant at Colonel's Island, Georgia. This new plant employs a unique process for utilizing a-pinene to produce products that formerly could only be made

with b-pinene. It produces terpenes of high purity and at a lower cost than traditional processes and is expected to be adopted as process technology for any future new turpentine refining plant.

The world market for alpha-pinene products has been depressed for nearly three years because of the following factors.

Pine oil is in oversupply in North America because of new production in Latin America, Mexico and Europe, which has displaced former U.S. export markets. High tariffs in Latin America make U.S. pine oil non-competitive in any case. China is an aggressive exporter of pine oil to Europe, undercutting the American exports. The pine oil market in North America is considered to be mature.

Polyterpene resins, introduced in the mid-1960's, compete with hydrocarbon resins. The latter has 90 percent of the combined market. The polyterpenes, while something like 50 percent more expensive, continue to make inroads into the market at a rate of about 2 percent per year while hydrocarbons show no growth. The applications tend to be mature, but stable with only hot melt adhesives and some concrete curing materials as new and growing uses for hydrocarbon resins.

Flavor and fragance terpenes, have begun meeting a strong challenge since about 1977 from petrochemical hydrocarbon substitutes. Two new world-scale plants devoted to hydrocarbon flavorant and aroma chemicals, have gone onstream since 1980. One is in West Germany, owned by BASF and the other is in Japan, run by Kuraray Corporation. Hoffman LaRoche has a 25 year old hydrocarbon flavorant plant in Switzerland. The hydrocarbon products are very competitive with terpenes, although production costs of the former are still a mystery. Terpenes are well-placed to compete on price with natural flavorants and fragances.

3.17.4 Major suppliers

BASF owns Fritzche Dodge & Olcott, a fragrance house in the States.

Cyanamid Canada owns John H. Breck, the toiletries firm marketing Pine-Sol in Canada.

Hercules processes turpentine in the U.S.

Northwest Petrochemical of Anacortes, Wash has control of the turpentine available from the B.C. mills.

Pfizer is involved in aroma chemical production in New York and may be interested in its own terpene source.

Record Chemical of Montreal has been the most aggressive in tying down turpentine supplies. It also does some distillation to clean up turpentine for solvent use.

Reichhold in Canada presumably has access to the technology utilized by Reichhold Chemicals at Pensacola.

SCM Corp is probably the strongest of the U.S. fractionators in the southeastern States.

Union Camp fractionates turpentine at Jacksonville, Florida.

3.18.0 Fermentation products

Beet sugar and molasses can serve as starting points for processes leading to the production of fine chemical products used widely in food, pharmaceuticals and toiletries as well as in specific industrial specialties (surfactants, etc.). Alberta devotes as much as 35,000 acres to the growing of sugar beets and more acreage could be assigned for this purpose under certain conditions.

3.18.1 The manufactured products

Many plants around the world employ deep fermentation of molasses to produce **citric acid.** The newer citric acid plants in the United States are in the 25 to 45 kt/year range.

Citric acid is probably the largest volume fermentation product made in the world. Its manufacture in Alberta is feasible only if the availability of a suitable glucose source such as beet sugar molasses can be assured.

Anhydrous citric acid is generally produced by direct crystallization. It is also commercially available as the monohydrate in the form of colorless, translucent crystals or white crystalline powder. The material is odorless, has an acid taste and is efflorescent in dry air. Grades available are U.S.P., crystals or powder, containing not less than 99.7 percent citric acids monohydrate, C.P. and anhydrous and a 50 percent industrial grade solution.Citric applications range from sequestering agent, to buffer, organic intermediate, plasticizer and detergent builder.

While citric acid was originally derived from citric juice in the late eighteenth century, all commercial production today is produced by fermentation (in shallow pans). This has proven to be an economical process and still accounts for much of current world-wide production. The submerged culture process (in deep tanks) has, however, become the preferred approach of the major processors when adding new capacity.

The one North American producer of **monosodium glutamate** (until 1983) used fermentation of beet molasses to produce L-glutamic acid, which is then partially neutralized to form the monosodium salt.

Monosodium glutamate (MSG) is one of the principal flavoring agents used in foods. It is used as a flavor enhancer for meats and is added to soups to improve the "mouth feel". It is used in the food processing industry fo a wide range of prepared foods that are cured, canned or frozen. It is also widely used by households in meal preparation and by institutions as well.

Monosodium glutamate is the sodium salt of the naturally occuring amino acid, L-glutamic acid. It is present in onions, beets, mushrooms, tomatoes and wheat gluten among other foods. Monosodium L-glutamate decomposes into L-glutamic acid and sodium chloride in human digestion. L-glutamic, thus formed, is metabolized as are normally digested proteins. MSG is soluble in water.

MSG has been accepted as GRAS ("generally recognized as safe") product since 1958. As a result of inconclusive experiments with mice, MSG has been voluntarily eliminated from prepared baby foods. MSG has been used by people on low sodium diets as a salt substitute but it is not specifically sold as such. While North Americans consume about 100 grams per year per capita, consumption in the Orient is generally ten times that amount. In 1983, North American demand exceeded 30 kilotonnes and sales at trade list prices topped U.S. $75 million.

Industrial production of MSG began in 1909 and until 1964 it continued to be hydrolyzed from crude dried wheat gluten which contains as much as 25 percent L-glutamic acid. In several countries, it was derived in this way from beet sugar. Hydrolyzation is referred to as the "classical process" and with few exceptions, it has been replaced by fermentation.

Sorbitol is obtained via the catalytic hydrogenation of either sucrose or **dextrose**. If sucrose is the raw material, **mannitol** is produced in association with sorbitol.

D-Sorbitol, a hexahydric alcohol, is a white hygroscopic solid having a pleasantly sweet cooling taste. It is soluble in water, glycerine and propylene glycol, slightly soluble in methanol, ethanol and acetic acid but insoluble in most organic solvents.

Sorbitol is available as 100 percent crystalline material and various concentrations of aqueous solutions.

The manufacturer of sorbitol usually begins with corn starch but other sources of glucose such as hydrolyzed starch can also be used. Supported nickel and Raney nickel are the catalysts. In the continuous procedure nickel or diatomaceous earth is added to a 50 percent solution of dextrose and after heating to 140 C. is pumped as a slurry into the reactor. Hydrogen is introduced to the reactor at the same time as the sugar solution is being added. As the catalyst is exhausted, it is collected and removed by way of a filter. The resulting solution is then purified.

Gluconate and other ions are removed as the solution flows over an ion-exchange resin bed. Then the solution is treated with activated carbon. This removes the remaining traces of organic impurities. Finally the solution passes through a continuous evaporator until 70 percent solids content is achieved. Further concentration and crystallization would obtain crystalline sorbitol. The aqueous solution is sold as USP XIX (trademake "Sorbo") and the crystallized product is sold as pellets or in a powder form.

A recent article quoted a major American producer as saying, "The process used now is basically considered a continuous system, the batch method being nearly obsolete. It is semi-continuous only in the sense that we buy refined dextrose and then we have to liquify it."

The sorbitol need not be separated as such after the hydrogenation reaction. In several plants around the world it is subject to selective oxidation, the sorbitol being first converted to L-sorbose, then to 2-keto-L-gulonic acid and then lactonized to **L-ascorbic acid** (Vitamin C). An ascorbic acid plant would need to have a capacity in the 4 to 5 kt a year range.

Ascorbic acid is the largest selling vitamin in North America. Over the period of the 1970's annual sales growth averaged 8 percent. This growth was stimulated by increased publicity regarding Vtiamin C (ascorbic acid) and an overall increase in the public's health concerns. North American demand during 1983 amounted to roughly 17 thousand tonnes and at current list prices (roughly $14.00 per kilogram) sales totalled between $200 and $250 million.

Microbial fermentation of barley bran or other substrates could result in the production of **enzymes** for food processing or other industrial uses.

Natural enzymes are derived from animals and plants, while artificial, i.e. microbial enzymes, are grown by fermentation of fungal or bacterial cultures. Microbial enzymes have assumed far greater importance than animal and plant enzymes during the past 25 years.

Animal enzymes are usually obtained from specific animal organs, e.g. lipase from the throat glands of calves and pancreatin from cow or pig pancreases. Plant enzymes are variously recovered from roots (horseradish), seed (malt), fruit (papain from papaya) or sap (ficin from fig trees).

Microbial equivalents have been developed for certain of the important animal enzymes, for example for the rennet obtained from the stomach of calves. Generally, however, the microbial enzymes were created for new food and industrial processes.

The fundamental process for producing enzymes is similar regardless of whether they originate from animal, plant or microbial fermentation sources.

The raw material for enzyme production is either delivered to the enzyme producer as animal organs or plants (or their fruits or sap) in the case of natural enzymes, or is fermented by the enzyme company from fungal or bacterial organisms in the case of microbial enzymes. Fermentation is carried out on a semi-solid medium or in submerged cultures contained in 5,000 to 50,000-gallon tanks. Proper control of pH, temperature, aeration and medium composition are critical to obtaining high yield and quality of microbial enzymes.

Processing of enzymes involves cell extraction, concentration, purification (in some cases), stabilization to ensure the desired life cycle, and finally standardization to the required enzyme activity level or potency. Extraction of enzymes from the natural or artificial medium in which they develop is achieved by various means, depending on the nature of the medium, including grinding following freezing, solubilization by surfactants or other means and subsequent washing out, or by ultrasonic cell rupture. In some cases, enzymes are not extracted from the source material. Malted barley, a source of amylase and starch for brewing, is simply dried and ground as is.

The extracted enzyme is in aqueous form from which the crude enzyme is precipitated using such solvents as acetone, methanol, ethanol and isopropanol. The concentration of solvent to aqueous extract is 0.5-1.5:1 for acetone and 2.5:1 to 4.0:1 for alcohols. Because the mixtures are unstable, precipitation is performed rapidly (in minutes) at very low temperatures (in the 0-10 C. range). The precipitated enzyme is then filtered in plate-and-frame filters using diatomaceous earth or by high-force centrifuging. The enzyme material is then dried rapidly, sometimes under vacuum, at temperatures in the 20-50 C. range.

FERMENTATION PRODUCTS, DERIVATIVES

Base chemicals	First-step intermediates
Sugar beets*	Beet molasses (sucrose)*
Corn or wheat*	Starch (dextrose)
Wheat*	Bran

Intermediates	Specialty products
Sucrose	Citric acid
Sucrose	Monosodium glutamate
Sucrose	Sorbitol + Mannitol
Dextrose	Sorbitol
Sorbitol	Ascorbic acid (Vitamin C)
Bran	alpha-Amylase

---

* already manufactured in Alberta

3.18.2 Alberta's strengths

Extension of Alberta's irrigation system could help expand the acreage producing sugar beet and therefore assure an adequate supply for the existing beet sugar refineries in the province. The premise is that any chemical processing would be integrated with one of those sugar refineries.

Alberta's Department of Agriculture, although sponsoring research on nutritional end-uses in the main, e seems eager to support work on industrial applications o beet sugar and its byproducts.

At least half the monosodium glutamate market in North America was served by offshore vendors (notably from Brazil and Taiwan) until Stauffer closed its California plant in 1983. An Alberta plant would have a transportation cost advantage supplying mid-continent consumers of MSG.

The citric acid currently manufactured in eastern Canada is dependent on calcium citrate being imported from Ireland. The economics of that facility are such that several offshore suppliers compete for the Canadian citric market.

The domestic sorbitol supply too is based on the upgrading of crude product imported from the U.S. as well as from refined grades originated in western Europe. All Vitamin C in bulk form is imported.

The U.S. market is similarily reliant on imports. Close to 40 percent of the ascorbic acid used south of the border was imported. Imports of sorbitol have been as high as 15 kt per year.

Sodium citrate, the largest volume salt derived from citric acid, has become a substitute for tetrapotassium pyrophosphate in liquid detergents.

3.18.3 Supply/demand balance

Consumption of citric acid, sorbitol and ascorbic acid in North America has risen impressively over the past several years.

3.18.3.1 Citric acid

Citric acid was the first commercially produced food acidulant. It continues to be the largest selling food acidulant but now has competition. Any estimates of future demand must take into account the availability and prices of substitute acidulants.

Canadian demand for citric acid can then be estimated to average 7 kt. This assumes that on a per capita basis, Canada consumes 2/3 of U.S. levels for food and beverages, 1/3 for pharmaceuticals and cosmetics, none for detergents, and 1/2 of U.S. levels for industrial applications. It is interesting to note that of all the citric acid plants built in the past decade, the smallest (Pfizer's Irish plant) had a capacity of 23 kt and the plant also produced calcium, sodium and potassium salts. Clearly, any economic scale plant in Canada must export at least two thirds of its output.

If current supply and demand patterns are extrapolated, the need for a new citric acid production facility will depend on the North American balance of trade. For example, North American consumption is currently estimated at roughly 127.2 to 147.1 kt/year. Production capacity is currently 181.2 to 188.0 kt. U.S. exports, net of imports, are 13.9. If 1984 imports and exports averaged 1980 levels, the domestic producers would be operating at 80 percent of capacity.

Before another greenfield plant would be feasible, the industry will first have to absorb much of the unused citric capacity. Also, it would seem reasonable that when the industry recovers, Pfizer will double its citric acid capacity at its Southport plant in accord with the plant's original design and planning. This expansion would add a further 45.6 kt of capacity. At current market growth rates, it would be between 1989 and 1993 before a new plant was needed (alternatively using a continued annual growth rate between 3.5 and 6.0 percent).

It is noteworthy that Hoffmann-La Roche has been actively preparing for a U.S. plant since 1976. The pre-marketing of increasing volumes of citric acid produced at its Citrique Belge plant in Belgium was intended to open the way for ground-breaking in the late 1970's. The recession, the high cost of capital, the slower than expected growth in demand and the outflanking strategies of Miles' and Pfizer's expansions have put the new plant plans on hold. It is possible that a reversal of the rise of American currency, protectionist legislation in the U.S., rapid growth in industrial applications for citric or the demands of U.S. customers may force Hoffmann to make its move before 1989.

3.18.3.2 Monosodium glutamate

Monosodium glutamate production and demand is dominated by the Far East. North America accounts for less than 10 percent of the market. The addition of new capacity, the development of new markets and the pricing are set without reference to North America. Any consideration of adding production facilities in Canada or the United States must take into account the trends overseas.

3.18.3.3 Sorbitol

It is estimated that North American consumption of merchant sorbitol (as 70 percent solution) totalled 105,000 metric tonnes in 1983. At the mid-year f.o.b. list price of $1.10 per kilo, the North American sorbitol market was worth about Canadian $115 million per year. Because a third of the 205,000 tonne capacity for isolated sorbitol is used captively by ascorbic acid producers it is likely that the industry was operating at about three quarters of capacity.

The production and marketing of sorbitol is international in scope. The inability of any particular company or country to dominate production and set prices has produced a very competitive market. Some countries such as Mexico and Brazil are so desperate for foreign exchange that they will accept any price in order to maximize exports.

With the industry in North America now operating at less than 60 percent of capacity, there does not appear to be much need for a new plant. Nonetheless, conservative estimates of demand growth would indicate the need for a new plant by 1990. Optimistic projections tend to recommend site development work as early as 1986. While current capacity is estmated to be 205 kilotonnes/year, the United States Department of Agriculture estimate of an annual growth in demand of 5 percent, would push capacity utilization beyond 80 percent in early 1990. This assumes that the North American market continues the recent trend to more imports and fewer exports.

3.18.3.4 Ascorbic acid

Canadian consumption of ascorbic acid has grown rather well in the past decade. Imports of bulk Vitamin C were about 700 tonne (worth $7.5 million), reached 882 tonne in 1982 and should have exceeded the 1,000-tonne mark in 1983. The current level of demand in the U.S. market is in the 16-kt/yr range. The annual rate of increase will continue at about the present rate of 5 to 6 percent per year. The maturity of applications for most food and beverages will mean that this industry will not expand its use of ascorbic by such percentages but the health food/vitamin applications will run ahead of the average growth rate.

Currently ascorbic acid demand is dominated by drug industry purchases. A 1980 estimate put pharmaceutical demand at roughly 60 percent of U.S. consumption. Food and beverage demand, generally, averaged 32 percent. This category includes many applications unrelated to ascorbic acid's vitamin supplement role. The remainder, or about 8 percent, was destined for export markets. Since 1980 the high value of the U.S. dollar has hurt exports and aided imports but the split between pharmaceutical and food and beverage uses is probably stable.

Ascorbic acid consumption in the U.S. market since 1970 is presented below to illustrate this continued pattern of growth.

Table 3.2

Consumption of ascorbic acid in the United States

Year	Consumption (kilotonnes)	5 Year Increase (percent)
1960	2.3	--
1965	3.6	60.0
1970	6.5	80.0
1975	8.6	31.9
1980	13.2	53.7
1985 *	16.8	26.7

* 1985 consumption is estimated

On the horizon there are opportunities and challenges for ascorbic acid. In its role as an antioxidant in foods, ascorbic acid is now challenged by the cheaper erythorbic acid and sodium erythorbate. In turn, dextrose prices have tripled since 1970 and despite increased efficiencies in processing, this has put upward pressure on ascorbic acid pricing. An opportunity has been presented by the increasing public concern over the ill-effects of salt consumption. The Food and Drug Administration in the U.S. has suggested that ascorbic acid and potassium bicarbonate in food processing could provide the same taste effect as sodium.

If the American dollar fell in relation to foreign currencies or the Japanese yen rose in value against the dollar, much of the recent gains by imports could be squeezed out of the North American market. If the current level of imports were halved to about 4.5 kt/year (the 1975 level), the American capacity utilization would jump from its 60 percent level to almost 80 percent. At this level a new North American plant could be considered.

Between the end of 1983 and early 1988, current forecasts anticipate an increase of 4,500 tonne in annual North American ascorbic acid demand. While that level of demand would not require only a third of the output of a plant the size of Roche's Scottish plant, it would nonetheless be sufficiently large for economic production. Pfizer's plant in Groton can produce less than half of 4.5 kt per year.

3.18.3.5 Enzymes

Growth in world-wide demand for industrial enzymes in the developed countries has been exceptional in most end-uses in the past 25 years. The historical growth rates of 10 percent or greater in most enzymes has moderated to the 5 percent level in the past five years as many markets, especially in food processing, have headed towards maturity. The dairy, meat processing and pharmaceutical industries are examples. Bakery use of enzymes has fallen off in the U.S. to 1 or 2 percent annually.

Nevertheless there are still industrial sectors whose use of enzymes is expected to continue growing at 5 percent or better for the next five years, even though this is well below past growth patterns. Detergent use of enzymes in the U.S. is projected to grow substantially, retrieving a market lost in the past 10 years because of unfavorable publicity on alleged ill effects from dusting effects of enzymes in powdered detergents. Where in 1968 45 percent of U.S. detergents had enzymes, only 10 percent contained them in 1980. The new acceptance of enzymes and the virtual doubling of enzyme concentrations to the 0.4 to 0.7 percent range (because of lower wash temperatures and reduced phosphate use) will ensure demand growth. On the other hand, the European market for detergent enzymes is mature.

High-fructose corn syrup production has seen spectacular growth in the U.S. in the past five years and so as a consequence has the demand for the three enzymes used in the process, namely bacterial amylase, glucoamylase and glucose isomerase. These enzymes have experienced annual growth rates of better than 15 percent. They are also used in the production of gasohol from vegetable wastes -- another starch conversion process.

Growth in U.S. consumption of these starch conversion enzymes is expected to moderate to 5 to 8 percent annually. Two new corn syrup production plants have been built in eastern Canada in the past three years. It remains to be seen whether a western Canadian plant is viable. Such a venture has been the subject of discussion, with the western soft drink bottling industry seen as a major incentive.

In assessing the need for a new enzyme production facility in North America, it should be noted that two new plants have gone on stream during 1981 and 1982 -- by Miles Laboratories and Novo, two of the enzyme industry giants. Gist-Brocade of the Netherlands also has acquired a U.S. manufacturing base through the acquisition of the facilities of Wallerstein, renaming the company GB Fermentation Industries. One effect of a strong European manufacturing presence in the U.S. has been to increase American enzyme exports to Canada from 50 percent in 1980 to 75 percent currently, with a concomitant decline in Canadian imports from Europe.

3.18.4 Major suppliers

Ajinomoto is the world's major force in MSG, the company manufacturing in both Brazil and Japan. It has licensed some of its technology to Stauffer.

Atkemix, the ICI subsidiary that processes sorbitol in Brantford, Ontario, markets both sorbitol and mannitol. The basic production from glucose is carried out at New Castle, Delaware.

CPC International, the Canada Starch parent, controls Maizena Industrie Produkte, which makes sorbitol in West Germany. Canada Starch wet mills corn at Cardinal and at Port Colborne, Ontario and will be involved in the Zymaise syrup plant at London as well.

Hoffmann-LaRoche is the major force in ascorbic acid with plants in West Germany (Grenzach), Scotland (Dalry) and the U.S.A. (Belvidere, New Jersey).

Miles Laboratories, the Bayer subsidiary, manufactures citric acid at Dayton, Ohio and Elkhart, Indiana. The company has two enzyme production units in the States and is involved in joint ventures in Mexico, West Germany and Argentina.

Nikken Fine Chemicals makes up to 25 kt/year of sorbitol in Chita, Japan.

Novo Industri of Denmark has enzyme production units in the U.S.A. and Switzerland.

Oriente of Brazil is a large producer of MSG and is also linked with the company making the flavor enhancer in Taiwan.

Pfizer Canada operates the small citric acid plant at Cornwall, Ontario. It also produces citric in Groton, Conn and Southport, NC in the States and in Ringaskiddy, Ireland. Pfizer also makes sorbitol at Groton and is in the enzyme business as well in Milwaukee.

Roquette Freres is the largest producer of sorbitol in the world. Its French plant (Lestrem) is being augmented by new capacity in the United States.

Stauffer Chemical was the sole U.S. producer of MSG (at San Jose, California) until early 1984.

Takeda Chemical in Japan is that country's sole Vitamin C producer.

Towa Kasei Kogyo, manufacturing sorbitol in Fuji, Japan, has a diverse product line (including xylitol) based on sorbitol.

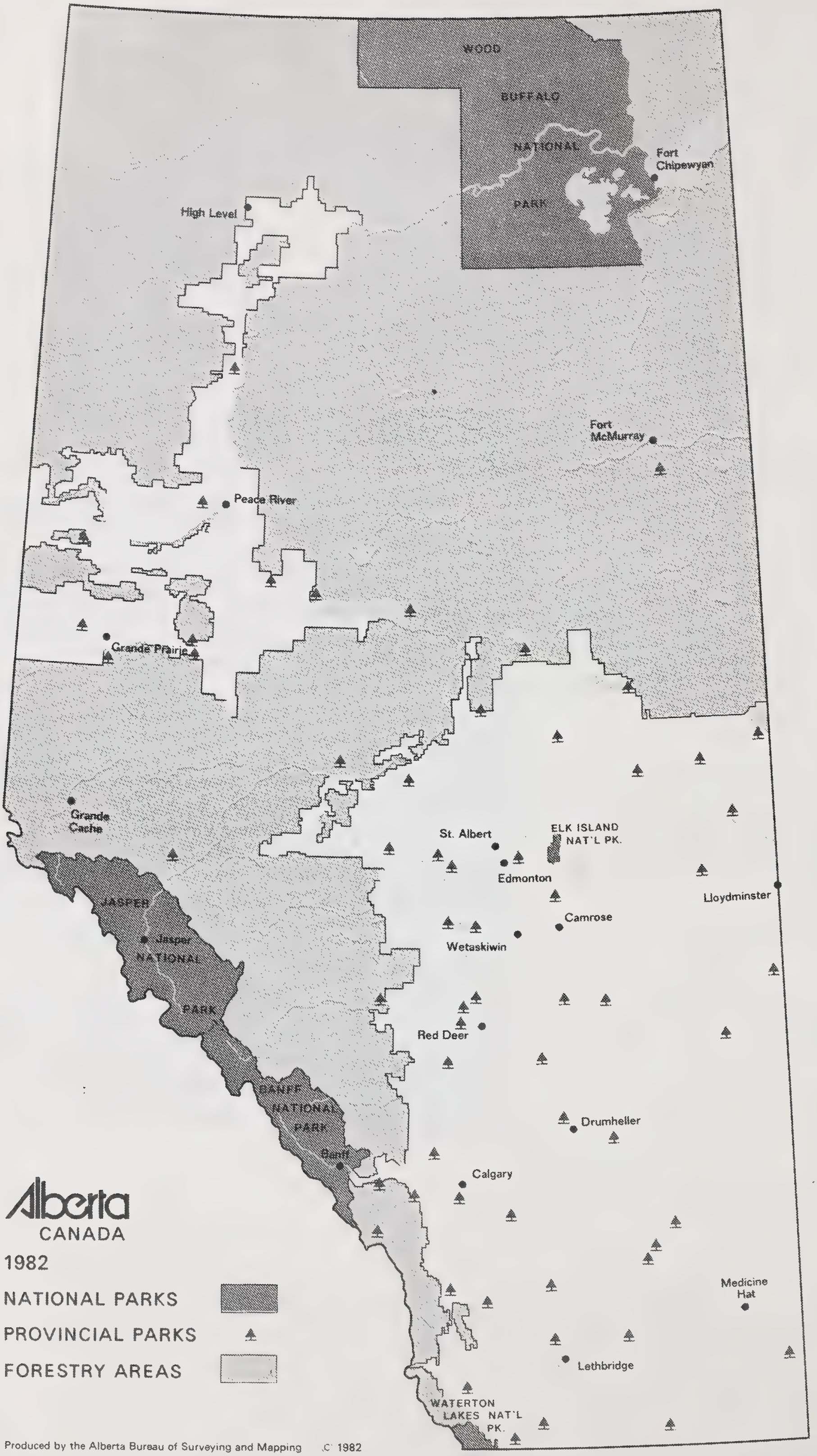
APPENDIX I

The Province of Alberta

ECONOMIC DEVELOPMENT

INTRODUCTION

- The Province of Alberta, Canada. It has a total area of 660,000 square kilometers, nearly three times the size of West Germany.
- Alberta is a land of diversity. From flat prairie, to rolling hills, to mountains; from near desert to excellent cropland and forested wilderness. The climate is primarily continental, similar to that of West Germany. There are, however, large areas which could more accurately be described as temperate.
- For all its size, Alberta has a population of only 2.3 million.
- More than half of the population lives in our two major centres, Edmonton and Calgary, each with a population of over 600,000. These cities have all the social and cultural amenities of urban living, and yet you are never more than an hour's drive from the enjoyment of the countryside.
- Our province has an abundance of resources. Prime agricultural land, vast large stands of marketable timber and extensive resources in coal, petroleum and natural gas.
- Alberta is committed to developing its economy by making full use of all of its advantages. It is committed to ensuring these advantages continue to operate for the long-term benefit of investors.
- Alberta's resources are being developed with an eye to the future — to build facilities, to provide necessary capital formation, and to maintain our rewarding quality of life.
- Taking advantage of all of their resources, Albertans today share in Canada's highest per capita income.
- The Alberta advantage. We measure it in quality and in bottom line results.



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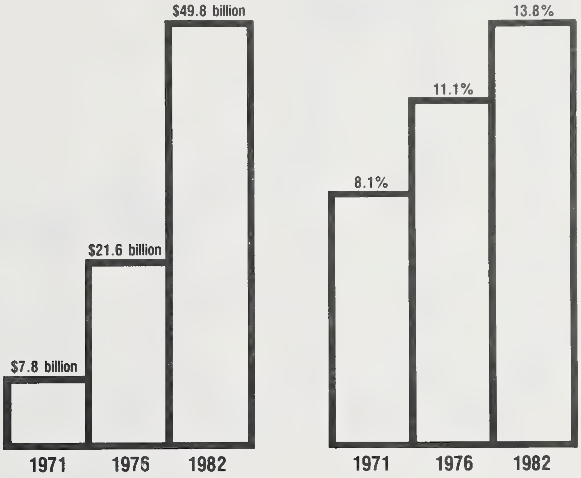
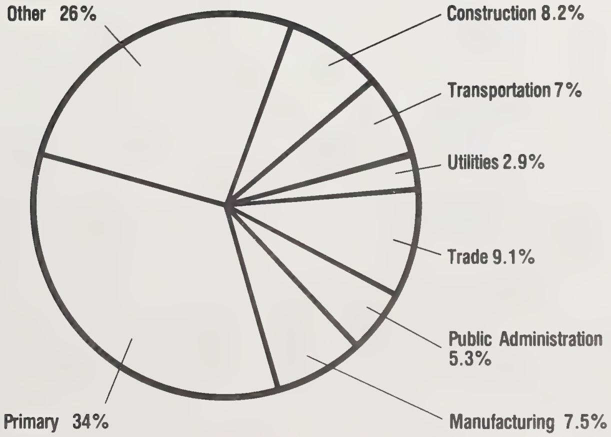
THE ECONOMY OF ALBERTA



GROSS DOMESTIC PRODUCT

GDP AS % OF CANADA

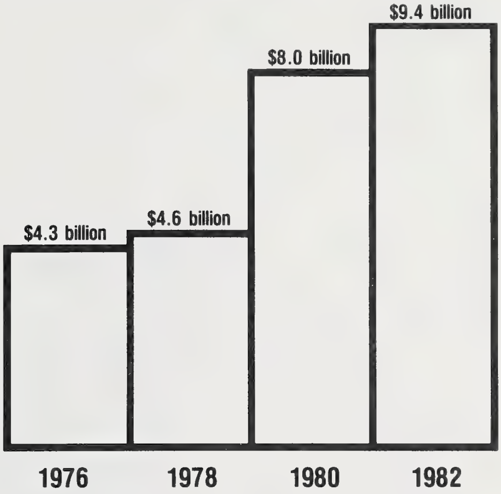
COMPOSITION OF GROSS DOMESTIC PRODUCT
1982 (Estimate)



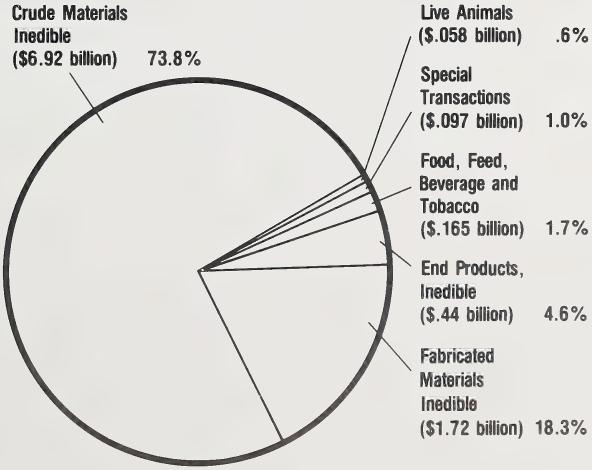
THE ECONOMY

- To show you Alberta's potential, we will begin with an overview of the province's economic structure and past performance.
- Spurred largely by the growth of resource related industries, Alberta's economic performance has, over the past years, been the strongest in Canada. Since 1971 the real Gross Domestic Product has increased at an average annual compound growth rate of 5.6%, and stood at about $49.8 billion at year-end 1982. At the same time, Alberta's share of the Gross National Product (GNP) rose from 8% to nearly 14%.
- The primary industries, oil and gas, mining, forestry and agriculture, are the major contributors to Alberta's GDP, with an estimated 34% in 1982. Manufacturing, trade, and construction have also made significant contributions.

ALBERTA EXPORTS, ALBERTA AS PROVINCE OF LADING



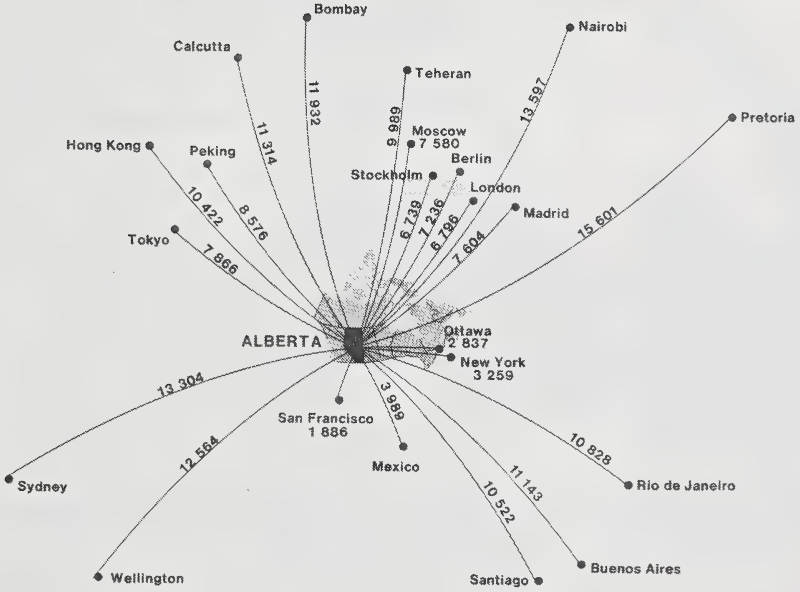
ALBERTA EXPORTS BY COMMODITY GROUP, 1982



MARKETS

- Alberta benefits from its proximity to the United States. Within a few hours we can access this market of over 220 million people. We are closer to both New York and Los Angeles than they are to each other!
- Thanks to modern transportation facilities Alberta is also particularly well situated to serve today's international market. It is only hours away from Tokyo, Moscow or Berlin.
- In 1982 Alberta's exports to other countries reached $9.4 billion, more than double the value recorded in 1976. This, even though last year's global economic downturn had caused a decrease from 1981.
- Over 80% of our exports presently go to the United States. In the past few years export markets for Alberta products have diversified. Several other countries are gaining importance as trading partners. Exports to Hong Kong, West Germany, and Brazil are growing at a very rapid rate.
- Alberta's 2.3 million people represent approximately 10% of the Canadian market.
- Our local market is concentrated in the two major centres and has a per capita personal income of about $12,500, roughly the same as that in the United States. Alberta has the most advantageous personal and corporate tax structure in Canada.

Alberta
IN THE WORLD



GREAT CIRCLE DISTANCES IN KILOMETRES

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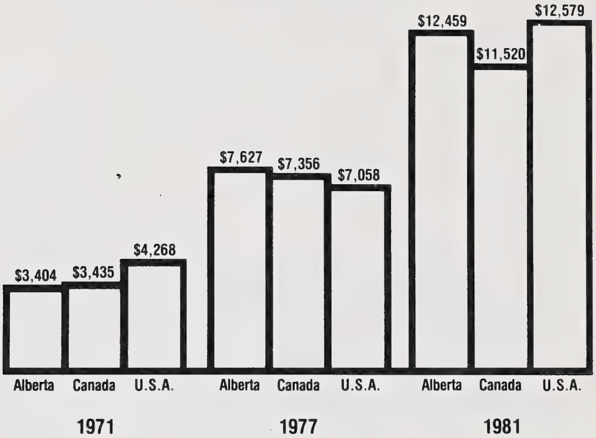
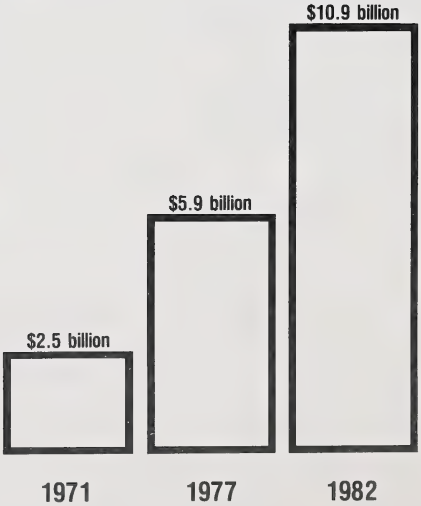
PER CAPITA PERSONAL INCOME
($ Canadian)



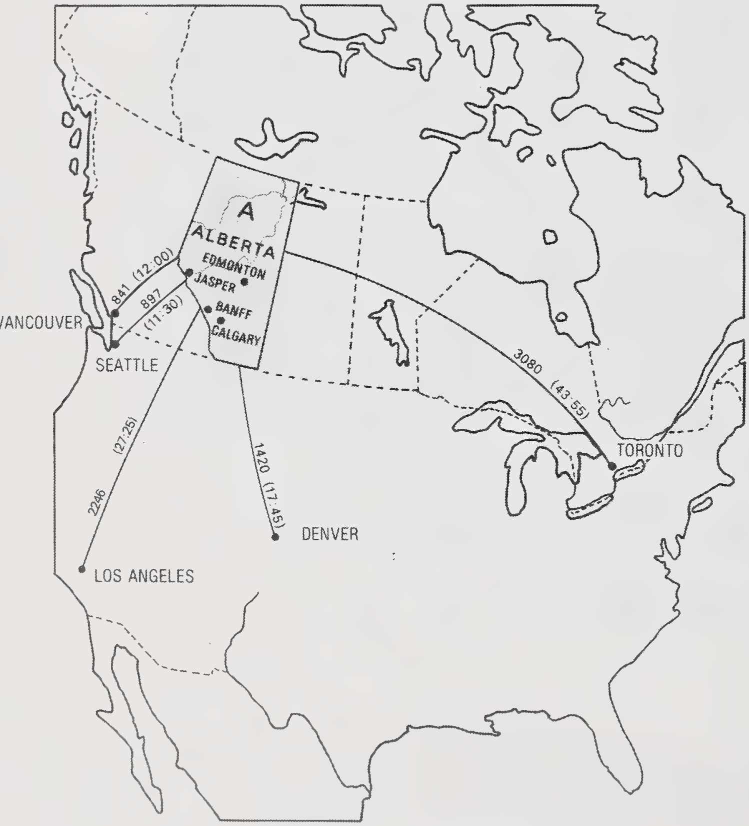
RETAIL TRADE IN ALBERTA



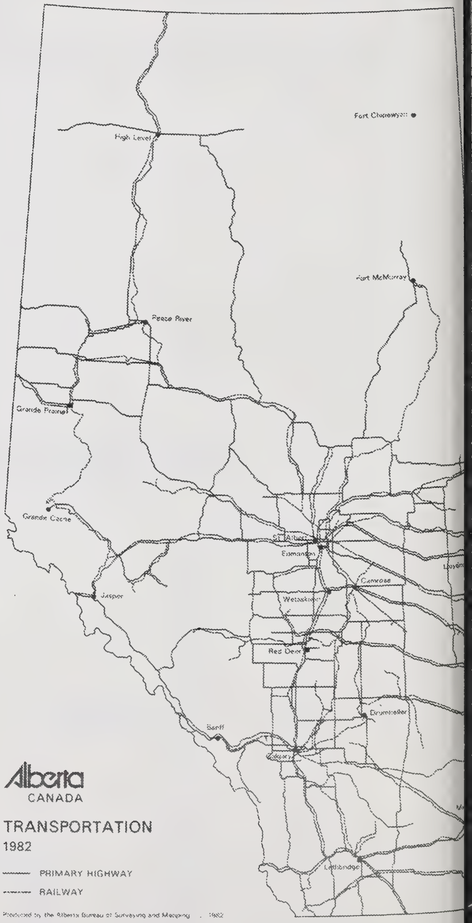
TRANSPORTATION/ COMMUNICATIONS

- Alberta has developed a world-class transportation and communications infrastructure.
- Alberta maintains an extensive highway system which connects the province to markets throughout Canada and the United States.
- The structure of freight transport to and from Alberta gives manufacturers in the province a special advantage. A truck bringing goods into Alberta must return empty unless return goods (back haul) can be arranged. Most carriers treat this freight as incremental revenue, so rates are very competitive, sometimes as little as a quarter of the forward haul.
- Local, regional and international markets are also linked by high quality rail service.
- Alberta has two international airports serviced by 6 major and a number of minor airlines. Lufthansa Airlines has just recently introduced direct service to Calgary. Our province has over 800 licensed and unlicensed airfields to serve the smaller communities.
- Alberta is at the forefront of communications technology. Microwave communications and telexes are all highly developed and bring national and international markets within easy reach.

DISTANCES IN KILOMETRES AND AVERAGE DRIVING TIMES FROM PRINCIPAL CENTRES IN NORTH AMERICA TO THE ALBERTA BORDER



Average driving times are in brackets.



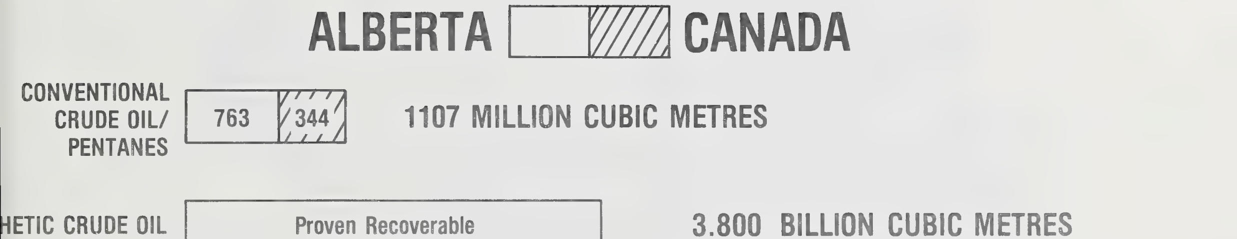
LABOUR FORCE

- In 1982 our labour force numbered 1.2 million, the highest labour force participation rate in Canada. This work force is highly skilled, trained and educated. In 1982 Alberta had 20,000 registered engineers, geophysicists, and geologists.
- In 1981 the province had roughly 10% of the country's labour force but accounted for only 2% of man days lost through work stoppage.

RESOURCES

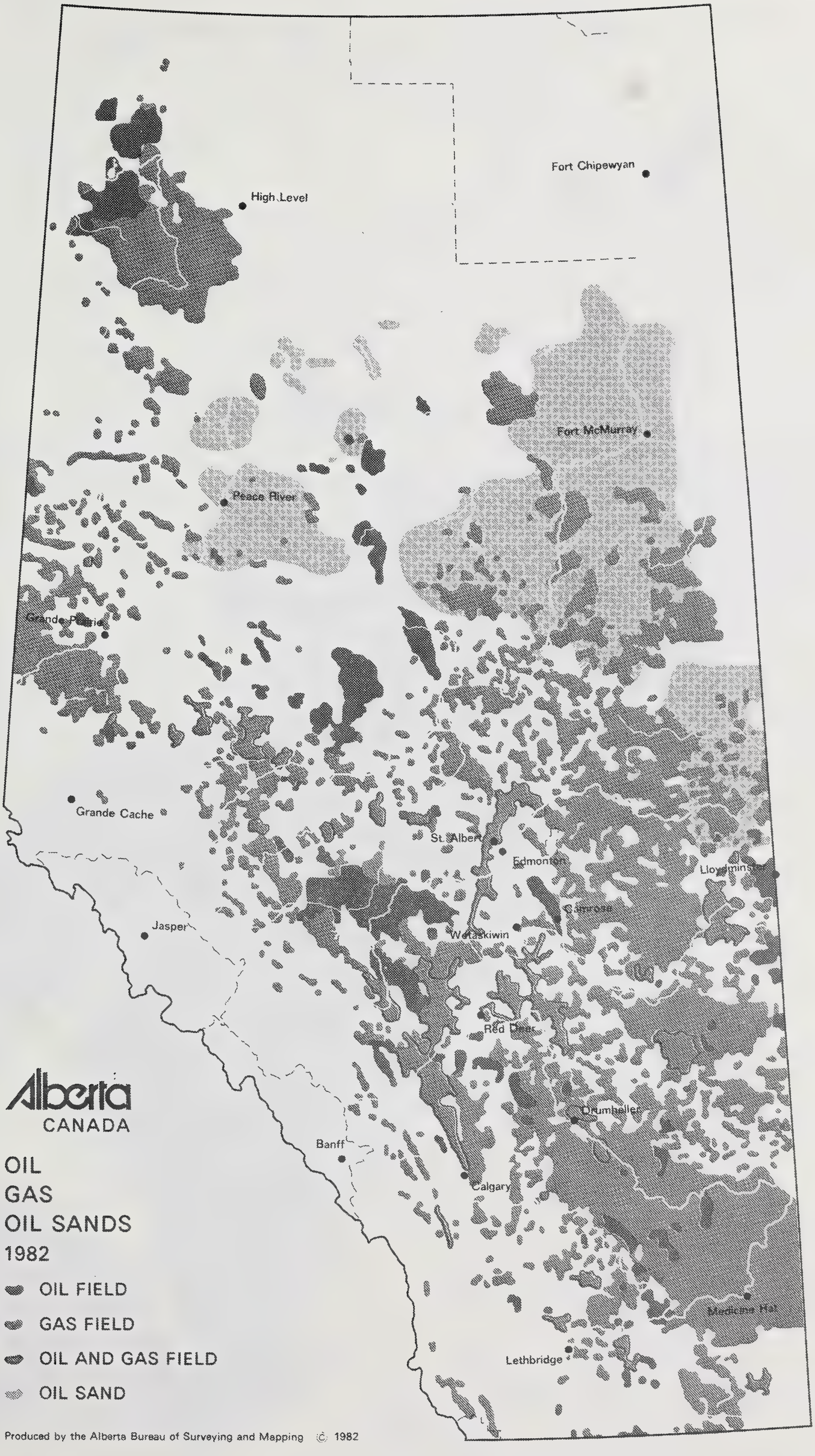
- The extraction of primary resources and the production this involves are the major contributors to Alberta's GNP. Great opportunities lie in the processing of these resources and the supply and service of those industries which extract them.

ALBERTA'S ENERGY RESOURCES AT DECEMBER 31, 1982



I. Energy

- Alberta is Canada's energy province. Large reserves of oil, natural gas, coal and tar sands underlie the province, and substantial potential exists for hydroelectric generation. Hydrocarbons are one of the few substances that can be used as both fuel in production and feedstock.
- Estimates for 1982 indicate remaining established conventional crude oil and pentanes reserves of 763 million cubic meters. This represents 68 percent of Canada's total.
- Synthetic crude oil, or tar sands, represents one of the great opportunities in Alberta's future. 3.8 billion cubic meters have been proven recoverable to date. A further 159 billion cubic meters await only the necessary technology to be classed as recoverable.
- With 2.6 trillion cubic meters of natural gas reserves, Alberta supplies most of Canada and large areas of the United States with this resource. Plans are underway to liquify and export gas overseas. Our stable supplies of reasonably priced natural gas have fostered the development of what is now a world-scale petrochemical industry producing everything from fertilizer to plastics.
- Alberta has 1.6 billion tonnes of metallurgical coal and 12.4 billion tonnes of thermal coal.
- Thermal coal and natural gas have been the source of over 91% of our electricity generation. The established potential for hydro capacity is 6,500 megawatts. This is more than eight times its current development and greater than Alberta's total electricity capacity in 1981.



Alberta
CANADA

OIL
GAS
OIL SANDS
1982

- ● OIL FIELD
- ● GAS FIELD
- ● OIL AND GAS FIELD
- ▨ OIL SAND

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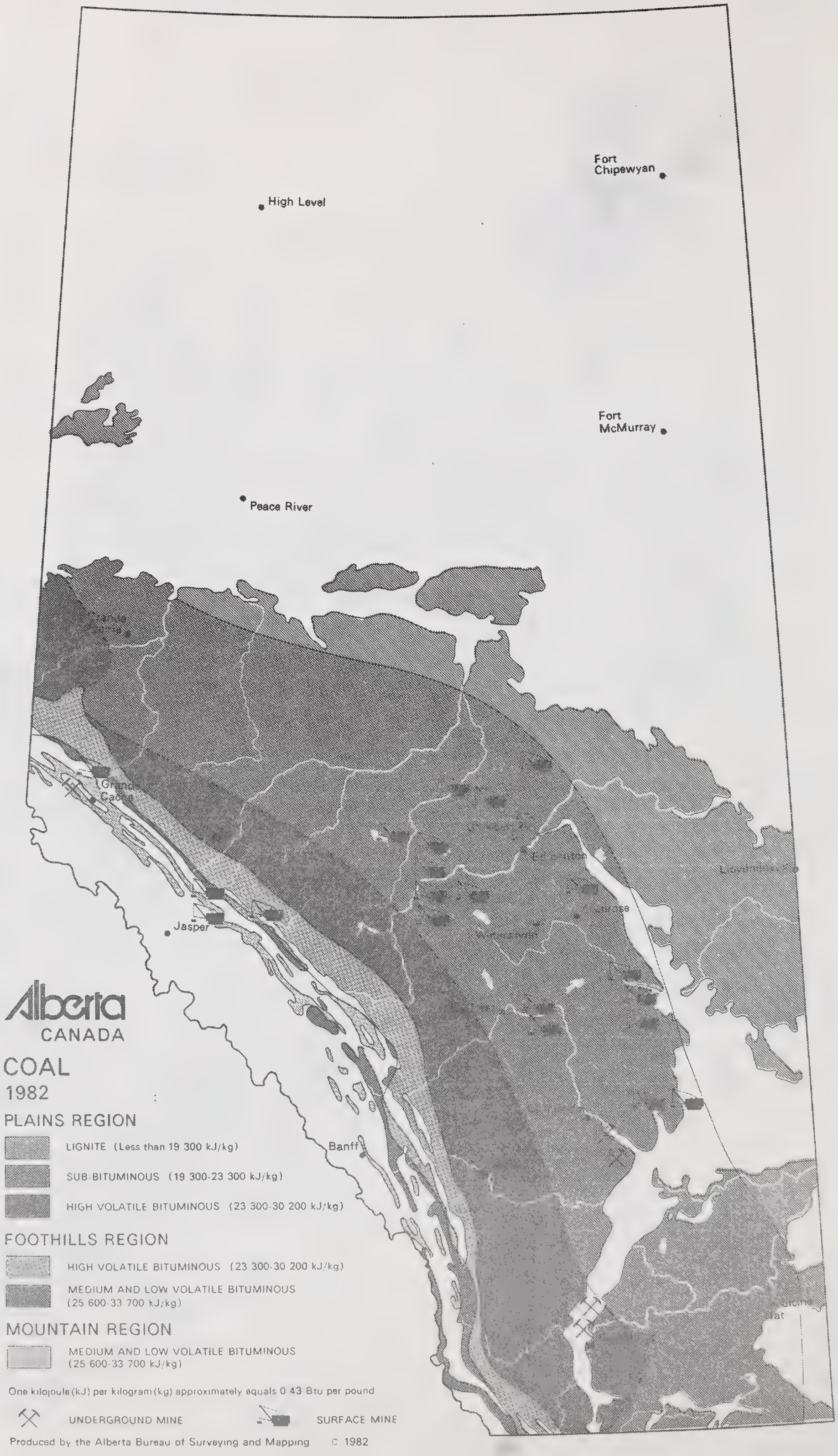
Fort Chipewyan
High Level
Fort McMurray
Peace River
Grande Cache
Edmonton
Jasper
Banff
Alberta CANADA
PLAINS REGION
LIGNITE (Less than 19 300 kJ/kg)
SUB-BITUMINOUS (19 300-23 300 kJ/kg)
HIGH VOLATILE BITUMINOUS (23 300-30 200 kJ/kg)
FOOTHILLS REGION
HIGH VOLATILE BITUMINOUS (23 300-30 200 kJ/kg)
MEDIUM AND LOW VOLATILE BITUMINOUS (25 600-33 700 kJ/kg)
MOUNTAIN REGION
MEDIUM AND LOW VOLATILE BITUMINOUS (25 600-33 700 kJ/kg)
UNDERGROUND MINE
SURFACE MINE

COAL
1982

One kilojoule (kJ) per kilogram (kg) approximately equals 0 43 Btu per pound

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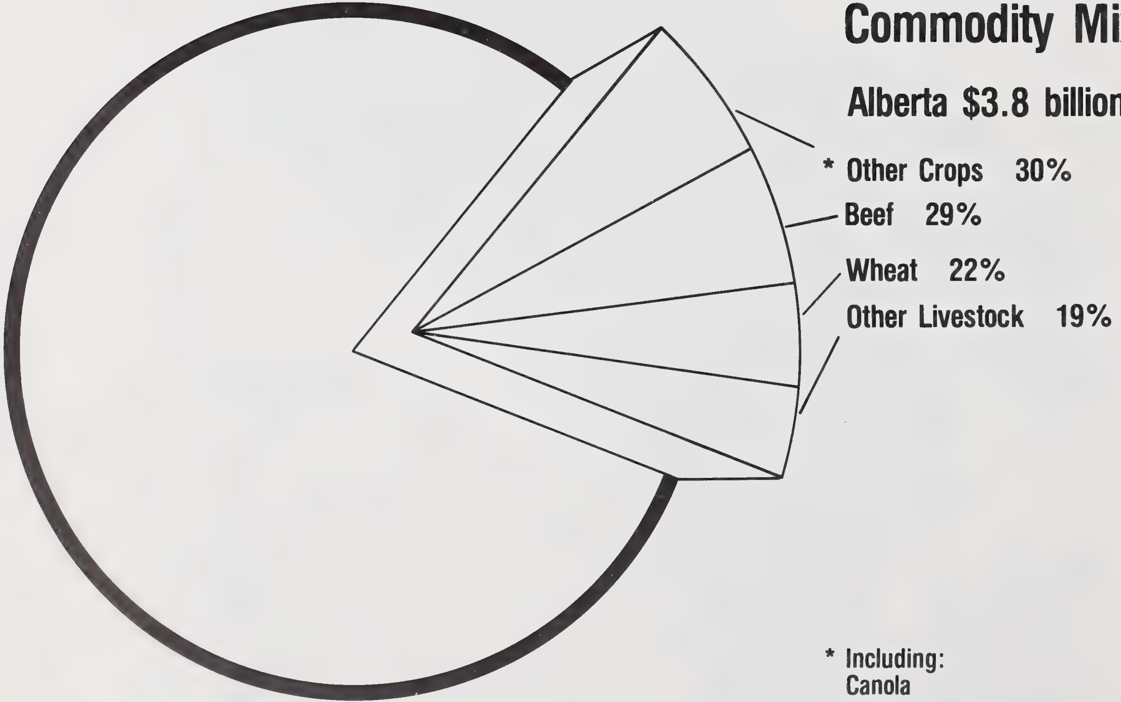
II. Agriculture

- Alberta produces 20% of Canada's total agricultural output. Products include fruits, vegetables, grains such as, barley, rye, flaxseed, canola, and livestock (especially beef).
- These agricultural resources provide a secure and economical supply for a wide variety of food processing operations. There is capacity to support greater development in this area.

AGRICULTURE 1982

Value of Alberta's vs. Canada's Agriculture Output

Alberta's Agricultural Commodity Mix

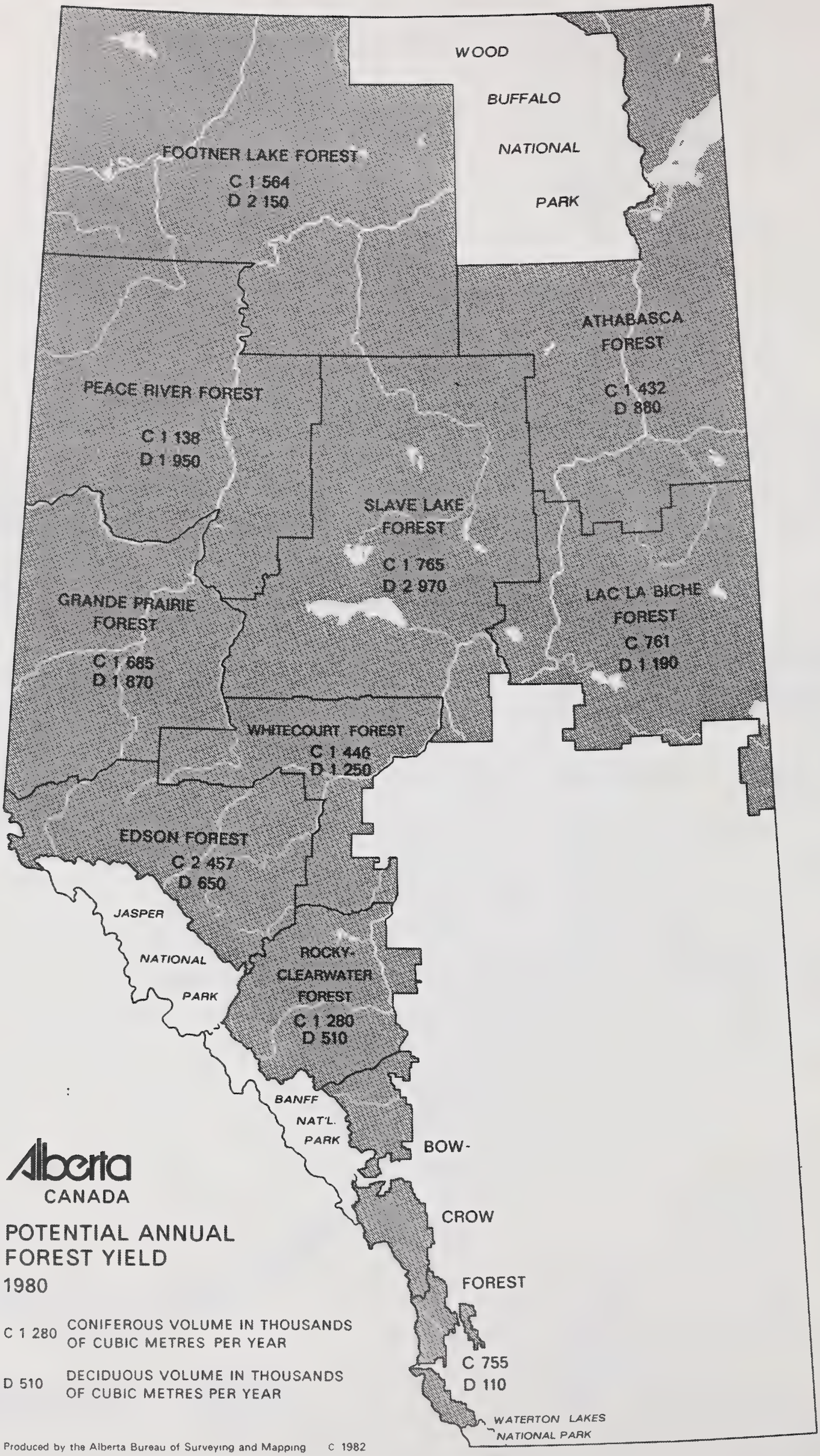


Total Canada $19.2 billion

* Including:
Canola
Barley
Flaxseed
Tame Hay
Rye

III. Forestry

- While Alberta is considered to be a prairie province you can see that 60% of the land (390,000 square kilometers) is covered with trees.
- These forests contain nearly 1.7 billion cubic meters of wood material. Alberta ranks fourth among Canadian provinces in terms of merchantable timber volume, and productive forest area.



Alberta
CANADA

POTENTIAL ANNUAL FOREST YIELD

1980

C 1 280 CONIFEROUS VOLUME IN THOUSANDS OF CUBIC METRES PER YEAR

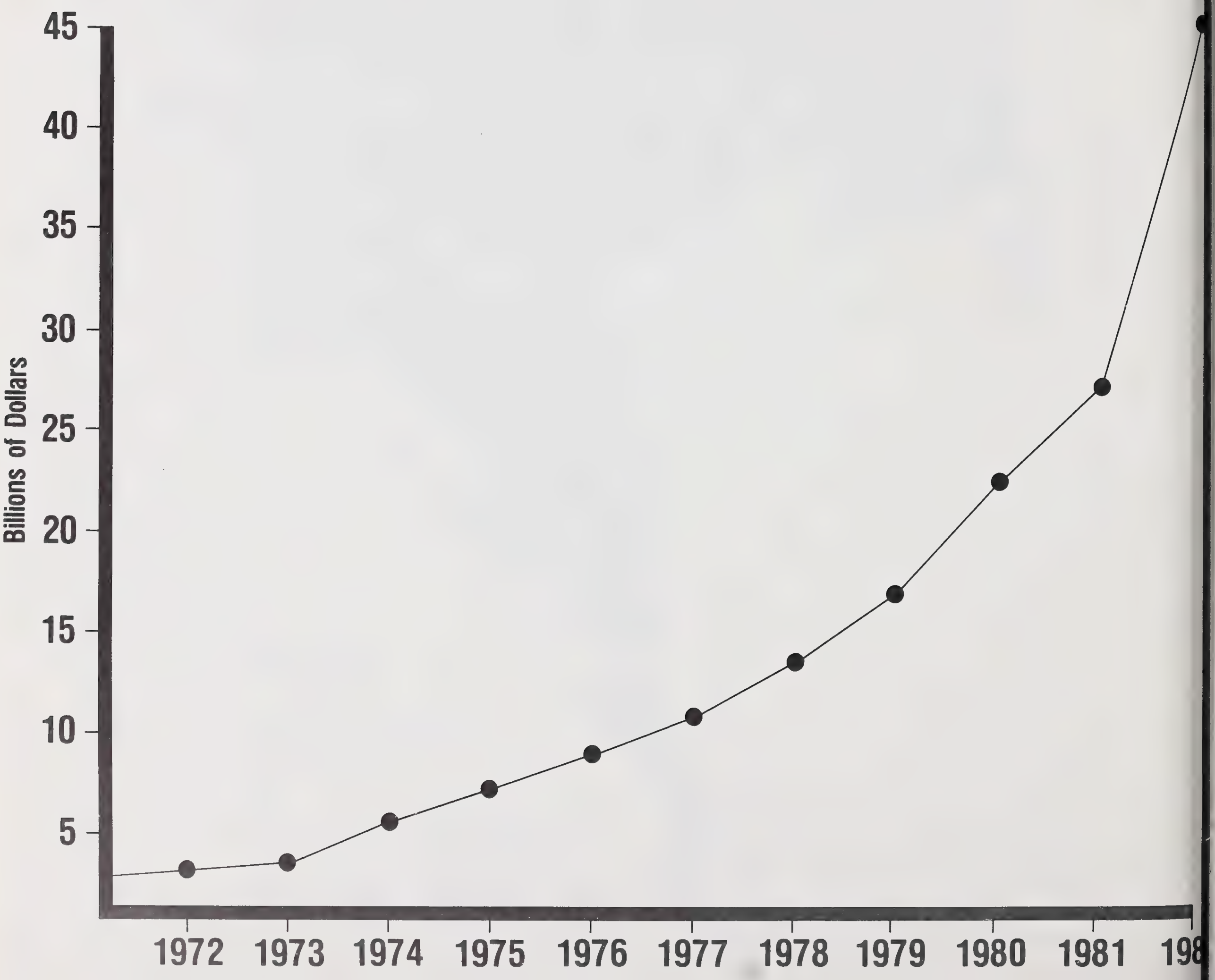
D 510 DECIDUOUS VOLUME IN THOUSANDS OF CUBIC METRES PER YEAR

Produced by the Alberta Bureau of Surveying and Mapping © 1982

FINANCIAL SECTOR

- Alberta plays a major part in Canada's dynamic financial market. Of four stock exchanges across the country, which provide equity for business, one is in Alberta. Chartered banks are also well represented throughout the province. Over the years Alberta's share of Canada's chartered bank assets has increased to its present 11.5% level.
- Many of Canada's banks are active in the international market, some rank among the largest in the world. Many foreign banks maintain offices in Alberta, including Credit Lyonnais, Credit Suisse, Barclays Bank, Chase Manhattan, and the Hong Kong Bank.

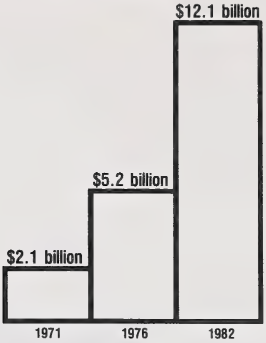
CHARTERED BANK ASSETS IN ALBERTA



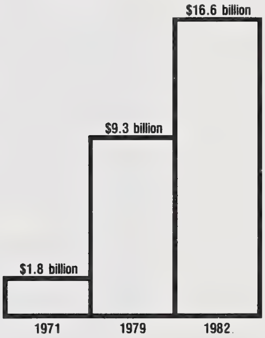
MANUFACTURING/ CONSTRUCTION

- The advantages of being situated in Alberta can be seen in the performance of the province's growing manufacturing sector. Since 1971, the sector has averaged an annual real growth rate of 7.5%. In 1982, the value of manufacturing shipments exceeded $12 billion. During the same 11 years, employment more than doubled.
- Because of Alberta's strong resource base, petroleum-related and food and beverage industries account for well over 50% of the value of manufacturing shipments.
- Over the past several years, manufacturing has diversified, with the metal-based and chemical-related industries showing particular strength.
- For the future, manufacturing opportunities will range from food processing, through oilfield equipment, to high-technology industries.
- The advantages of the Alberta economy are also shown in the growth of the province's construction industry. In 1982 the value of construction work reached $16.6 billion, up from $1.8 billion in 1971. Even after adjusting for inflation, this represents a real rate of growth of nearly 12% annually.
- Historically construction has been split evenly between building and engineering construction. Growth has resulted from the rapid population increases and the larger resource-based industrial projects such as tar sands developments and petrochemicals.

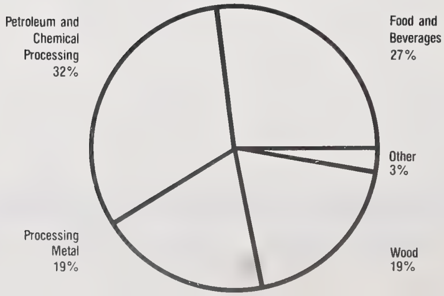
MANUFACTURING VALUE OF SHIPMENTS



VALUE OF CONSTRUCTION



COMPOSITION OF MANUFACTURING
1982 (ESTIMATE)



GOVERNMENT

- Let us now look at the structure of the Alberta and Canada governments; Alberta's economic strategy and the services and programs provided by our province.

STRUCTURE:

- Canada's ten provinces and two territories are linked by a federal system of Government. Federal and provincial governments each have distinct, defined areas of jurisdiction. The provinces have jurisdiction over most natural resources, health, education, property, and civil rights.
- The Alberta Government, like the rest of Canada, has inherited the tradition and practices of British parliamentary democracy. The Legislative Assembly is the body which makes Alberta's laws.
- The province has a history of great political stability.

ECONOMIC STRATEGY

- Balanced Regional Growth
- Resource Development
- Optimum Resource Upgrading
- Diversification
- Small Business Development
- Tourism Development
- Development of Alberta as a Financial Centre
- Development of Technological Capabilities
- Gateway to the North

ALBERTA'S ECONOMIC STRATEGY

- The cornerstone of Alberta's approach to economic policy is the firm conviction that it is the private sector which makes the economy grow. Accordingly, the greatest concern has been for establishing a stable business climate which is conducive to investment and growth. One way in which this has been achieved has been through the corporate tax structure, one of the most lenient in Canada.
- With this belief in the private sector in mind the following economic strategy has been developed.

Balanced Regional Growth

- About 50% of Alberta's population lives in the two major cities of Edmonton and Calgary. To equalize economic and employment opportunities and maintain the vitality of rural life, the province has been actively promoting other centres for industrial development.

Resource Development

- Alberta's strong growth history has been largely based on the energy and agriculture sectors. These will continue to form the basis of future growth.

Optimum Resource Upgrading

- Our province will continue to promote further resource upgrading activities. This program has met with considerable success to date, as is evidenced by Alberta's climb to its present position as a world-scale petrochemical producer.

Diversification

- For all the vast reserves of energy, the province realizes that hydrocarbons are a non-renewable resource. Accordingly, economic diversification is being actively pursued.

Small Business Development

- Small businesses have been and will continue to be the backbone of Alberta's economic growth.

Tourism Development

- Tourism was one of the industries targeted by the province for diversification and has seen strong growth to date.

Development of Alberta as a Financial Centre

- Banking and finance are not only an essential component of our infrastructure, but important industries in their own right. As indicated earlier, Alberta's rapid growth throughout the 1970s has led to large increases in banking activity and to a higher level of decision making by bankers in the province.

- Alberta hopes to attract more foreign banks to the province and to see further strides in the responsibility of Alberta branches.

Development of Technological Capabilities

- As part of its diversification strategies, and in recognition of the changing economic and technological environment, Alberta is encouraging a broader, stronger technological base.

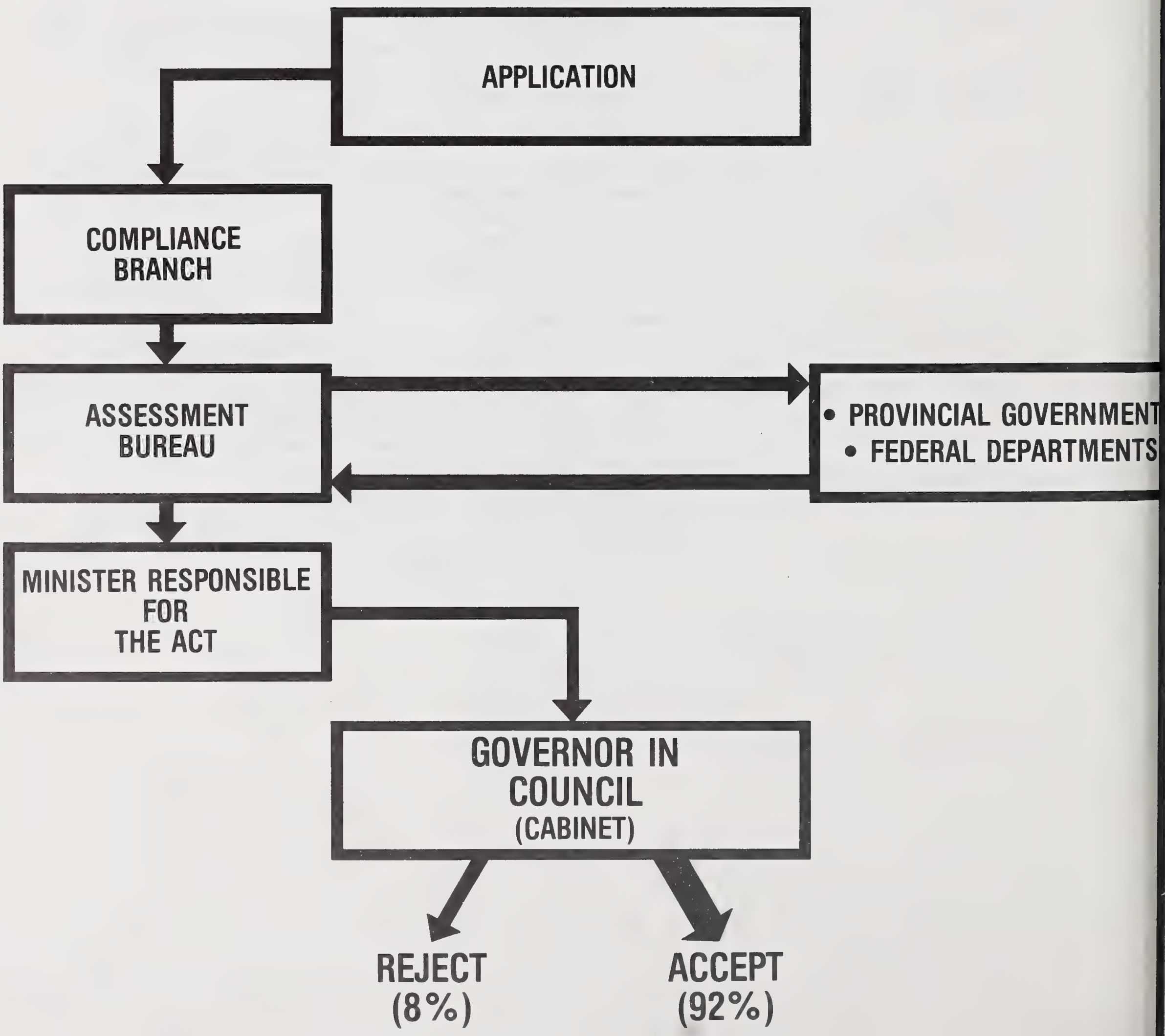
GOVERNMENT PROGRAMS AND SERVICES TO BUSINESS:

- Most important is the continued maintenance of a healthy business climate. Together with our markets, workforce, resources, and Government-supported infrastructure, this is one of Alberta's strongest selling points.
- A number of government agencies, both Federal and Provincial, are equipped to gather, analyze and disseminate information for the purpose of furthering the industrial development of the province.
- Several agencies are prepared to give assistance — both financial and practical, in selecting industrial sites, starting or expanding production, developing markets, supplying technical information, developing products or production processes, and in industrial design. Some specific examples:
  - Vencap Equities Alberta Ltd. was created by the Alberta Government to address the need for greater availability of venture capital. Originally capitalized at $240 million, the corporation will be run at arm's length from the Government.
  - The Alberta Heritage Savings Trust Fund was established in 1976 as a savings account for a rainy day. Fifteen percent of our non-renewable resources income goes into this account yearly. Among its activities are the $300 million Medical Research Endowment Fund and the Capital Projects Program, which finances the further development of infrastructure necessary for diversification.
- Several agencies are involved in research and development activities, including:
  - Alberta Oil Sands Technology and Research Authority
  - Alberta/Canada Energy Resource Research Fund
  - Interdisciplinary Environmental Research and Services
  - Farming for the Future
  - Alberta Research Council
  - Federal/Alberta Microelectronic Development and Application Centre

INVESTMENT IN ALBERTA

- Perhaps the most important factor in Alberta's economic performance is you, the investor.
- Alberta's economy might best be described as investment-led. Twenty-four billion dollars were invested in 1982, up from $2.7 billion in 1971. Foreign investment has always been an important component of this total.
- Foreign investment in Canada falls under the Federal Investment Review Agency (FIRA). This organization was first established in 1973 to review and assess the acquisitions of Canadian business enterprises and the establishment of new businesses by non-Canadians.
- Investors are required to file applications with the Federal Government which are reviewed by both Ottawa and the affected province. In the past, 92% of all applications have been approved.
- Alberta has always approached each case individually and openly encourages foreign investments which will further our goals of strengthening free enterprise, diversification, balanced regional growth, and the expansion of the small business sector. **Alberta works with each investor and makes every attempt to expedite the approval process.**
- In recent years, and mainly as a result of provincial encouragements, the FIRA application process has been streamlined to significantly speed up the process and reduce the paper burden on applicants.

FIRA REVIEW PROCESS



LIFESTYLE IN ALBERTA

- The economy is not, however, the only reason that people from all over the world have chosen to live in Alberta.
- Alberta is the mountains — for climbing, for skiing. It is unspoiled northern wilderness for camping, fishing, hunting, and hiking. It is the southern badlands, a picturesque near-desert that contain one of the world's richest deposits of dinosaur fossils, and it is lakes and rivers to accommodate all types of water sports.
- Alberta is also dynamic cities which offer the full range of urban entertainment. Choose from 12 professional theatre companies, a mime troupe, 5 professional dance and 2 professional opera companies as well as 2 professional symphony orchestras, numerous galleries and 3 major museums.
- For sports fans, Alberta offers professional hockey, football, soccer and baseball as well as international events such as the 1988 Winter Olympics.
- Most important, Alberta is communities, and peaceful neighbourhoods where a family can grow.

APPENDIX II

STATISTICS FOR CHEMICAL IMPORTS INTO CANADA
DURING 1981 AND 1982

SC code	Imported product	Volume (in mt)		Value (in $000)	
		1981	1982	1981	1982
4099410	(2,4-dichlorophenoxy)acetate	55	331	126	874
4069824	1,1,1-Trichloroethane	2415	1758	1150	1477
4069832	1,1,2-Trichloroethane	97	81	38	55
4084022	1,1,3,3tetramethoxypropan	2	6	4	16
4127812	1,2-Benzopyran	2	0	7	0
4129550	1,3-Propanesultone,in bulk	0	0	0	0
4116442	1,3-diphenylguanidine	157	50	707	207
4127343	1-Phenyl-3-pyrazolidinone	2	17	15	124
4099714	12-hydroxy stearic acid	179	196	271	276
4132682	17-Methyltestosterone	0	2	37	35
4099750	2(2,4,5-T)propionic acid	0	0	0	0
4099754	2(4C2MP)propionic acid	21	49	77	168
4126343	2(Morpholinothio)benzothio	186	166	1069	724
4122981	2,2-Thiodiethanol	1	0	2	0
4099755	2,4,5-T phenoxyacetic	0	10	0	2
4188220	2,4,5T+2,4,5T ester formulated	0	2	0	6
4188410	2,4-D amine salts,formulated	1923	4624	3709	8495
4188215	2,4-D+2,4-D ester,formulated	764	2935	1810	8787
4188820	2,4-D/2,4,5-T mixtures,form	263	66	545	316
4079536	2,6-Dimethyl-4-heptanol	4	2	6	7
4114916	2-Amino-2-methyl-propanol	120	143	237	26
4115967	2-Chloro-4-nitrobenzamide	1	0	3	0
4095817	2-Ethylhexoic acid	685	399	951	622
4090324	2-Ethylhexyl acrylate	450	358	716	651
4126311	2-Mercaptobenzothiazole	39	25	125	85
4127335	2-Pyrrolidone	11	65	39	358
4085931	2-ethyl-3-propylacrolein	0	0	0	0
4117851	2-hydroxyethylhydrazine	2	0	0	0
4112667	3,3-Dichlorobenzidine	20	5	158	58
4115957	3,5-dinitro-o-toluamide	10	0	85	0
4099753	3-6-dichloro-o-anisic acid	0	1	0	18
4127333	3-Amino-1h-1,2,4-triazole	37	34	191	146
4127916	4,4-dithiodimorphine	25	34	204	233
4081357	4,4Isopropylidenediphenol	519	564	1031	1051
4132036	6-methylprednisolone	32	10	193	291
4233525	ABS emulsion	31	27	33	26
4233522	ABS molding compositions	2943	1286	4869	2448
4233520	ABS resin compounds	1066	704	1883	1251
4233590	ABS resin nes	1541	1436	2698	2888
4235925	ABS resin scrap+waste	698	422	681	371
4127745	Acenocoumarin,in bulk	7	3	3	38
4189536	Acephate,formulated insecticide	32	24	384	325
4212925	Acephate,technical	0	0	0	0
4232945	Acetal resins	962	639	3539	2614
4085922	Acetaldehyde	7157	5285	5813	4255
4085961	Acetaldol	0	0	0	0
4084090	Acetals,hemiacetals+deriv	9	12	23	39
4115963	Acetaminophen,in bulk	253	280	2020	2378

SC code	Imported product	Volume (in mt) 1981	1982	Value (in $000) 1981	1982
4115944	Acetanilide	19	1	56	6
4129154	Acetazolamide,in bulk	1	1	28	41
4090615	Acetic acid	511	414	353	317
4090689	Acetic acid derivatives	113	93	140	127
4090669	Acetic acid esters nes	340	556	452	637
4090639	Acetic acid salts nes	62	39	78	50
4090670	Acetic anhydride	17	1	14	1
4115940	Acetoacetanilide	2036	1472	4854	3577
4099742	Acetoacetic acid	5	4	1	1
4129153	Acetohexamide,in bulk	11	9	34	70
4117410	Acetonitrile	293	371	404	503
4115942	Acetophenetidin	4	5	1	1
4088940	Acetophenone	1	16	1	43
4099142	Acetyl tributyl citrate	3	1	12	1
4088912	Acetylacetone	44	70	129	327
4063330	Acetylene	1289	1339	384	457
4099310	Acetylsalicylic acid,bulk	958	869	3906	3766
4115920	Acrylamide monomer	538	589	832	1008
4233120	Acrylamide resins	4058	3595	8460	7219
4090315	Acrylic acid	0	0	0	0
4090389	Acrylic acid derivatives	150	12	232	29
4090339	Acrylic acid esters nes	410	518	1063	1439
4090349	Acrylic acid salts nes	102	45	307	109
4233179	Acrylic ester or acrylic	2140	2567	4716	6437
4233189	Acrylic resins nes	7841	7040	15241	14868
4117110	Acrylonitrile	18290	9220	17441	10327
4115939	Acyclic amides nes	288	175	1077	862
4114919	Acyclic amino alcohols+derv	414	549	941	1190
4083139	Acyclic ethers+derivatives	66	89	1145	2244
4088929	Acyclic ketones nes	410	289	928	971
4096039	Acyclic monoacid esters	64	286	144	359
4096019	Acyclic monoacid salts nes	12	0	77	0
4112529	Acyclic monoamines+derivatives	642	718	2187	2931
4098019	Acyclic polyacids nes	9	19	9	23
4112639	Acyclic polyamines nes	45	67	593	675
4095829	Acyclic saturated monoacids	1	1	0	0
4095839	Acyclic unsaturated monoacids	0	6	0	650
4290770	Additives for fuel oil	1583	1747	4646	4615
4290780	Additives for lube oil	28813	24753	54657	48354
4290775	Additives for motor oil	12071	8184	19556	16003
4290790	Additives,mineral oils nes	1064	1082	2350	2848
4215940	Adhesive,acrylic resin base	266	601	978	1419
4211990	Adhesive,animal base,nes	477	163	974	347
4211925	Adhesive,animal bone base	1430	818	2148	1104
4211935	Adhesive,animal hide base	1081	926	2513	1973
4215980	Adhesive,copolymer resin	700	788	1597	2206
4219915	Adhesive,dextrin base	5	12	10	17
4215920	Adhesive,epoxy resin base	257	281	1199	1112

SC code	Imported product	Volume (in mt) 1981	Volume (in mt) 1982	Value (in $000) 1981	Value (in $000) 1982
4211945	Adhesive,fish base	0	0	0	0
4215950	Adhesive,formaldehyde resins	110	92	138	218
4219937	Adhesive,mucilage	34	44	79	128
4219989	Adhesive,nes	3016	2339	7382	6244
4215960	Adhesive,polyethylene bas	111	58	313	194
4215930	Adhesive,polyvinyl acetate	199	601	460	1419
4217910	Adhesive,rubber base	1143	887	2784	2573
4219950	Adhesive,silicone base	30	49	185	265
4219919	Adhesive,starch base	65	1	75	4
4215990	Adhesive,synthetic resin	2077	2467	7339	8052
4219939	Adhesive,vegetable extracts	43	1	73	8
4219935	Adhesive,vegetable gum	4	1	14	4
4098015	Adipic acid	0	0	0	0
4117522	Adiponitrile	0	0	0	0
4132045	Adrenal cortical extracts	0	1	0	6
3999962	Agar-agar extract	53	110	181	253
4188970	Alachlor,formulated herbicide	383	2473	1184	13635
4114962	Alanine+alanine derivatives	15	2	48	80
4079729	Alcohol acids nes	77	95	236	361
4083289	Alcohol+ether peroxides+derv	396	176	900	629
4099749	Aldehyde acids or ketone	84	6	1267	785
4232929	Aldehyde resins nes	43	118	46	106
4085969	Aldehyde-alcohol compounds	79	21	97	44
4085985	Aldehyde-function compounds	38	16	128	45
4068310	Aldrin technical	0	0	0	0
4184045	Aldrin,formulated pesticides	0	0	0	0
4239961	Alginic acid	12	10	77	80
4239969	Alginic acid compounds nes	60	49	185	174
4239965	Alginic acid esters	68	92	487	892
4239963	Alginic acid inorganic salt	75	64	474	388
4059982	Alkali amides	1	0	7	0
4009935	Alkali/alkaline earth metal	784	170	1174	461
4109945	Alkyl aryl phosphate	9	54	27	152
4115960	Allantoin	4	5	70	59
4063334	Allene	3	1	1	1
4188973	Allidochlor,formulated herb	4	43	13	175
4127773	Allopurinol,in bulk	15	10	1038	1227
4079940	Allyl alcohol	1	2	1	0
4134015	Aloin,in bulk	3	2	10	4
4038439	Alum nes	66	6	71	7
4059845	Aluminium carbide	20	0	12	0
4090620	Aluminum acetate	71	8	112	10
4099131	Aluminum ammonium citrate	1	1	1	1
4038433	Aluminum ammonium sulfate	1055	602	460	331
4059932	Aluminum boride	5	20	1	14
4033625	Aluminum chlorhydrate	798	484	403	398
4033620	Aluminum chloride	246	365	142	173
4099127	Aluminum citrate	0	0	0	0

SC code	Imported product	Volume (in mt) 1981	Volume (in mt) 1982	Value (in $000) 1981	Value (in $000) 1982
4090223	Aluminum formate	0	0	0	0
4029921	Aluminum hydroxide	4082	3904	3008	3191
4029920	Aluminum hydroxide gel	559	597	650	703
4038431	Aluminum potassium sulfate	123	110	69	67
4094221	Aluminum stearate	36	41	53	63
4037310	Aluminum sulphate	2546	1937	531	232
4188824	Ametryn,formulated herbicides	0	0	0	0
4114979	Amino acids+derivatives	1027	1537	1586	2256
4114949	Amino naphthols+derivatives	4	1	13	0
4114959	Amino(aldehyde)(ketone)(quion)	28	5	317	152
4114939	Amino-phenols+derivatives	13	14	108	103
4114952	Aminoanthraquinones	0	0	0	0
4117731	Aminoazobenzene	9	6	46	39
4114951	Aminobenzaldehydes	3	2	0	6
4185622	Aminocarb,formulated pesticides	9	9	27	46
4115923	Aminocarb,technical	104	260	1047	1113
4114931	Aminophenol,para,ortho,meta	4	6	48	37
4135915	Aminophylline,in bulk	3	1	32	23
4127442	Aminopyridine	0	0	0	0
4112557	Amitriptyline+derivatives	3	3	1023	443
4020225	Ammonia gas	9	5	5	2
4020220	Ammonia, anhydrous	41118	32081	12283	9393
4020230	Ammonia, aqua	358	517	82	107
4090621	Ammonium acetate	17	74	21	110
4095732	Ammonium benzoate	7	7	10	0
4043733	Ammonium bicarbonate	253	407	82	122
4031926	Ammonium bifluoride	122	145	172	175
4032621	Ammonium chloride	2844	990	924	379
4098045	Ammonium iron-oxalate	0	0	0	0
4047981	Ammonium metavanadate	7	1	61	2
4164931	Ammonium nitrate	10937	10365	2095	1997
4098043	Ammonium oxalate	44	5	24	6
4038471	Ammonium persulphate	472	369	546	426
4165820	Ammonium phosphate(MAP)	119087	85628	34878	24759
4165829	Ammonium phosphates nes	20359	16533	5644	4740
4049559	Ammonium salts of inorg acids	153	176	148	205
4049555	Ammonium sulfide	3325	1946	714	570
4164810	Ammonium sulphate	15274	15063	1989	1658
4049556	Ammonium thiocyanate	47	68	68	115
4035930	Ammonium thiosulphate	964	983	229	299
4047913	Ammonium tungstate	39	32	332	790
4127765	Amodiaquin,in bulk	0	0	0	0
4112547	Amphetamine sulphate,bulk	0	0	0	0
4112546	Amphetamine,in bulk	1	0	2	0
4136352	Ampicillin,in bulk	153	16	3181	2435
4090641	Amyl acetate+isoamyl acet	87	86	138	149
4079925	Amyl alcohol + isomers	384	375	402	449
4122027	Amyl mercaptan (normal)	0	5	0	8

SC code	Imported product	Volume (in mt)		Value (in $000)	
		1981	1982	1981	1982
4098433	Amyl tartrate	0	0	0	0
4133035	Amylases+proteases,bulk	91	111	882	531
4132680	Androsterone,in bulk	2	0	0	0
4112540	Aniline	610	513	767	573
4112541	Aniline derivatives	309	257	1249	1012
4297090	Animal charcoal nes	546	626	632	711
4099756	Anisic acid	0	2	0	0
4083154	Anisole	3	1	17	1
4002530	Anthracene black	1	12	3	10
4136910	Antibiotics nes,in bulk	174	354	4315	6427
4098426	Antimony barium tartrate	0	0	0	0
4033622	Antimony chloride	0	4	0	0
4098225	Antimony lactate	0	0	0	0
4026110	Antimony oxides	0	0	0	0
4098424	Antimony potassium tartrate	19	14	232	191
4049569	Antimony salts of inorg acids	4	2	9	0
4049567	Antimony sulphides	14	2	36	15
4098427	Antimony tartrate	0	0	0	0
4135260	Apomorphine,in bulk	1	0	0	0
4004925	Argon	1482	1719	448	612
4079989	Aromatic alcohols	183	64	241	177
4085959	Aromatic aldehydes nes	50	36	355	275
4083159	Aromatic ethers+derivatives	44	27	129	81
4063379	Aromatic hydrocarbons nes	455	246	482	288
4088949	Aromatic ketones nes	7	16	12	27
4096049	Aromatic monoacid esters	38	8	53	14
4096029	Aromatic monoacid salts	0	16	0	15
4112569	Aromatic monoamines+deriv	214	88	1541	780
4098039	Aromatic polyacids nes	4	2	5	3
4112669	Aromatic polyamines+deriv	65	132	665	942
4055849	Aromatic saturated monoacids	69	34	4410	2608
4095859	Aromatic unsat monoacids	10	8	18	29
4004936	Arsenic	86	35	295	253
4019930	Arsenic acid	151	31	104	64
4051033	Arsenic chlorides	0	0	0	0
4059856	Arsenic hydride	0	0	0	0
4019920	Arsenic oxide	281	251	817	690
4051081	Arsenic sulphides	0	0	0	0
4114967	Aspartic acid+derivatives	1	2	2	14
4053246	Astatine/Halogen	0	0	0	0
4185625	Asulam,formulated pesticides	153	20	838	127
4127482	Atrazine, technical	469	736	1797	2446
4188830	Atrazine,formulated herb	2088	1719	5933	4105
4135945	Atropine,in bulk	86	102	4	5
4189859	Attractants,pest,formulated	88	48	293	163
4096310	Azelaic acid	603	483	1443	1226
4059879	Azides nes	0	0	0	0
4184057	Azinphos-methyl,formulated	67	50	650	320

SC code	Imported product	Volume (in mt)		Value (in $000)	
		1981	1982	1981	1982
4127520	Azinphos-methyl,technical	50	0	539	0
4188833	Aziprotryn,formulated herb	0	0	0	0
4117759	Azo-compounds nes	104	120	548	628
4117735	Azoformamide	69	61	332	261
4117779	Azoxy-compounds nes	16	3	87	9
4117762	Azoxybenzene	0	0	0	0
4182520	Bacillus thuringiensis	150	196	515	1285
4136625	Bacitracin,in bulk	20	2	109	106
4188965	Barban,formulated herbicibes	93	231	743	1720
4115962	Barbituric acid	2	5	8	1
4090622	Barium acetate	6	0	9	0
4059844	Barium carbide	0	0	0	0
4042710	Barium carbonate refined	3209	2500	1080	824
4032623	Barium chloride	1288	1616	434	475
4099123	Barium citrate	5	0	0	0
4021925	Barium hydroxide	268	229	216	173
4039134	Barium nitrate	46	11	26	11
4021920	Barium oxide	111	0	79	0
4011926	Barium peroxide	7	8	17	5
4049577	Barium phosphate	0	0	0	0
4049579	Barium salts of inorg acids	43	85	75	180
4094222	Barium stearate	5	28	9	81
4038420	Barium sulphate	1107	909	1001	682
4047951	Barium titanate	7	14	26	60
3940510	Beeswax	37	35	253	220
4095825	Behenic acid	20	35	45	79
4127530	Benazolin, technical	3	0	9	0
4129132	Bendroflumethiazide,bulk	0	1	0	1
4127532	Benomyl, technical	0	0	0	0
4185624	Benomyl,formulated pesticide	0	0	0	0
4184054	Bensulide,formulated pest	0	37	0	213
4188980	Bentazone,formulated herb	61	52	894	697
4085952	Benzaldehyde	13	26	30	49
4062110	Benzene	3172	317	2253	261
4069911	Benzenesulfonic acid	53	56	58	61
4112656	Benzidine	12	2	55	32
4099715	Benzilic acid	8	3	21	11
4127921	Benzimidazole	5	0	1	0
4095715	Benzoic acid	102	142	131	161
4095789	Benzoic acid derivatives	121	93	255	194
5095759	Benzoic acid esters nes	113	121	356	309
4095739	Benzoic acid salts nes	1	18	1	18
4088941	Benzophenone	51	29	162	131
4063367	Benzopyrene	0	4	0	0
4088960	Benzoquinone	42	4	65	38
4126341	Benzothiazole	19	40	87	162
4126349	Benzothiazole derivatives	188	59	1016	420
4126339	Benzothiazole-sulfenamide	7	16	53	110

SC code	Imported product	Volume (in mt)		Value (in $000)	
		1981	1982	1981	1982
4095760	Benzoyl chloride	196	188	381	412
4095762	Benzoyl peroxide	162	118	704	527
4188930	Benzoylprop ethyl,formulated	0	0	0	0
4114953	Benzoylprop ethyl,technical	0	1	0	1
4129133	Benzthiazide,in bulk	0	0	0	0
4135925	Benztropine mesylate,bulk	312	323	13	14
4090650	Benzyl acetate	22	15	48	30
4079980	Benzyl alcohol	129	193	273	369
4095740	Benzyl benzoate,in bulk	5	6	8	9
4069876	Benzyl chloride	86	71	123	100
4083156	Benzyl ethyl ether	0	0	0	0
4090233	Benzyl formate	1	0	1	0
4097945	Benzyl phthalate	2	2	2	2
4099916	Benzyl salicate	2	5	9	12
4120424	Benzyl xanthates	0	0	0	0
4127457	Betahistine,in bulk	3	9	25	75
4115230	Betaine	18	3	17	15
4132030	Betamethasone,in bulk	2	4	2997	2897
4116441	Bethanidine+bethanidine	5	0	1	0
4043720	Bismuth carbonate	2	1	3	2
4099767	Bismuth gallate, basic	4	22	8	40
4033640	Bismuth oxychloride	3	8	6	15
4099766	Bismuth salicylate,basic	3	4	7	10
4049619	Bismuth salts of inorg acids	5	0	25	0
4156979	Blasting agents nes	0	0	966	468
4156971	Blasting caps except military	0	0	574	62
4297020	Bone black	123	81	142	87
4168922	Bone flour	164	139	71	58
4188221	Borate base formulated herb	0	6	0	1
4013120	Boric acid	6742	7131	4492	5235
4013130	Boric oxide	33	8	16	27
4059939	Borides nes, metallic	19	11	8	44
4079975	Borneol	3	0	0	0
4090651	Bornyl acetate+isobornyl	26	11	52	21
4069883	Bornyl chloride	0	0	0	0
4090231	Bornyl formate	0	0	0	0
4099914	Bornyl salicylate	0	0	0	0
4059851	Boron hydride	0	0	0	0
4059861	Boron nitride	15	77	21	145
4059832	Boron phosphide	2	0	0	0
4051053	Boron trifluoride	8	7	41	38
4049927	Borotungstates	70	4	43	0
4127474	Bromacil, technical	2	2	7	6
4133063	Bromelain,in bulk	2	2	38	63
4051040	Bromides of non-metals	191	92	563	325
4004921	Bromine	1065	539	715	387
4095811	Bromoacetic acid	9	0	14	0
4069873	Bromobenzenes	9	44	26	146

SC code	Imported product	Volume (in mt)		Value (in $000)	
		1981	1982	1981	1982
4115911	Bromodiethylacetylurea	1	4	41	1
4069834	Bromofluorotrichlorethane	59	55	667	556
4069944	Bromonitromethane	4	0	0	0
4117820	Bromophenylhydrazine	3	0	0	0
4109972	Bromophos,technical	0	0	0	0
4069871	Bromostyrene	0	0	0	0
4069833	Bromotrifluoromethane	107	162	746	1157
4188964	Bromoxynil,formulated herb	421	434	1967	2339
4127612	Buquinolate,in bulk	0	0	0	0
4060910	Butadiene	15595	7305	10517	4541
4060725	Butene 1	1821	998	1412	769
4060726	Butene 2	70	3	55	3
4090640	Butyl acetate and isobutyl	2297	1907	2490	2215
4090321	Butyl acrylate	5980	5194	8671	7866
4079923	Butyl alcohol isomer mixture	1	1	1	1
4072110	Butyl alcohol, normal	355	240	248	171
4097925	Butyl benzyl phthalate	2194	1504	2902	2055
4081354	Butyl catechol	225	56	368	316
4083213	Butyl cellosolve	537	542	585	546
4099141	Butyl citrate	10	1	1	0
4083745	Butyl glycidyl ether	45	8	91	36
4098232	Butyl lactate	23	5	77	14
4122031	Butyl mercaptans	45	3	77	6
4090422	Butyl methacrylate	961	607	2136	1358
4097934	Butyl octyl phthalate	0	2	0	3
4095255	Butyl oleate	0	4	0	0
4099924	Butyl parahydroxybenzoate	9	4	1	15
4225060	Butyl rubber	10656	5765	21908	12507
4099917	Butyl salicylate	0	0	0	0
4094242	Butyl stearate	3	1	5	2
4098432	Butyl tartrate	0	0	0	0
4185654	Butylate,formulated pest	0	837	0	3762
4083245	Butylated hydroxyanisole	25	17	476	355
4080350	Butylated hydroxytoluene	251	199	953	614
4097942	Butylcyclohexyl phthalate	8	2	8	4
4083740	Butylene oxide	54	93	260	474
4060790	Butylenes nes	134	66	43	21
4112645	Butylphenylphenylenediamine	5	0	1	0
4085921	Butyraldehyde	1	26	2	43
4095812	Butyric acid	1	7	15	11
4123346	Cacodylic acid+its salt	1	1	4	4
4059972	Cadmium amalgam	0	0	0	0
4029924	Cadmium oxide	38	22	195	66
4049629	Cadmium salts,inorg acids	1	1	2	10
4094223	Cadmium stearate	0	4	0	4
4049627	Cadmium sulphide	8	4	45	26
4135975	Caffeine+its salts,bulk	90	97	906	997
4009930	Calcium	24	50	48	186

SC code	Imported product	Volume (in mt)		Value (in $000)	
		1981	1982	1981	1982
4090623	Calcium acetate	12	20	21	18
4049636	Calcium arsenate	0	0	0	0
4184021	Calcium arsenate,formulated	1	0	5	0
4095735	Calcium benzoate	0	0	0	0
4059931	Calcium boride	2	1	33	21
4059843	Calcium carbide	8108	1716	3594	1009
4043722	Calcium carbonate ex whiting	2156	1557	814	504
4032220	Calcium chloride, dry	7144	9096	1807	2098
4032222	Calcium chloride,liquid	4126	3750	373	304
4099121	Calcium citrate	0	0	0	0
4164932	Calcium cyanamide,25% or<	122	91	24	23
4044920	Calcium cyanide	1	0	0	0
4199160	Calcium cyanide,formulated	1	0	1	0
4040625	Calcium di-phosphate	917	44	411	24
4090222	Calcium formate	231	99	95	39
4099762	Calcium gluconate, bulk	48	55	168	195
4109941	Calcium glycerophosphate	5	8	28	18
4059853	Calcium hydride	53	0	27	0
4029931	Calcium hydroxide	62	47	67	44
4033810	Calcium hypochlorite	3876	3523	8529	2451
4049637	Calcium hypophosphite	15	1	24	4
4098221	Calcium lactate,in bulk	0	0	0	0
4096022	Calcium linoleate	0	0	0	0
4047961	Calcium molybdate	0	0	0	0
4040620	Calcium mono-phosphate	3245	6304	1469	3100
4298720	Calcium naphthenate	89	0	115	0
4039133	Calcium nitrate	6903	6543	1331	1338
4164933	Calcium nitrate,under 16%	4475	5181	835	1032
4098044	Calcium oxalate	0	0	0	0
4029930	Calcium oxide	4	2	15	5
4029932	Calcium peroxide	2	5	8	21
4040690	Calcium phosphates nes	4262	3022	2052	1571
4059833	Calcium phosphide	0	0	0	0
4091021	Calcium propionate	253	204	278	299
4049639	Calcium salts,inorg acids	247	20	586	74
4045721	Calcium silicates	505	309	393	224
4094226	Calcium stearate	208	213	269	265
4038417	Calcium sulphate dihydrated	23	54	24	45
4098425	Calcium tartrate	5	0	9	0
4047911	Calcium tungstate	0	0	0	0
4185112	Calomel,formulated fungicide	0	0	0	0
4088931	Camphor	52	31	150	98
3944933	Candelilla wax	61	51	112	135
4136461	Capreomycin,in bulk	0	0	0	0
4095823	Capric acid	46	17	67	25
4095816	Caproic acid	69	4	89	0
4127963	Caprolactam	9649	9076	16192	15655
4231525	Caprolactam spinning chip	1624	750	3985	1830

SC code	Imported product	Volume (in mt) 1981	Volume (in mt) 1982	Value (in $000) 1981	Value (in $000) 1982
4095820	Caprylic acid	113	54	148	85
4096012	Caprylic acid salts	89	66	172	164
4185833	Captafol,formulated fungicide	240	156	676	602
4185831	Captan,formulated fungicide	117	118	422	198
4127650	Carbamazepine,in bulk	6	6	1535	1308
4115971	Carbaryl, technical	80	82	371	472
4185623	Carbaryl,formulated pesticide	250	137	875	641
4059849	Carbides nes	8	35	244	102
4127614	Carbinoxamine,in bulk	1	1	6	4
4185621	Carbofuran,formulated pest	1288	915	5708	3858
4136473	Carbomycin,in bulk	0	0	0	0
4053222	Carbon 13	0	8	91	158
4053241	Carbon 14	3	1	286	35
4002520	Carbon black	9267	7432	7629	698
4009924	Carbon dioxide	1952	3029	654	727
4051025	Carbon oxychloride	1	1	2	2
4051082	Carbon sulphides	12	19	3	5
4069826	Carbon tetrachloride	740	261	233	82
4109969	Carbonic ester salts+derivs	51	120	595	1298
4127522	Carboxin, technical	40	35	682	608
4238920	Carboxymethylcellulose	2584	2188	8000	7254
3941510	Carnauba wax	146	114	402	338
4239930	Casein hardened from natural	32	21	99	65
4236410	Cellulose acetate	11285	8497	16081	13140
4236610	Cellulose acetate butyrated	760	713	2518	2519
4238939	Cellulose esters+ester nes	249	419	1210	1904
4236210	Cellulose nitrate,exc exp	2595	2032	5717	4797
4238989	Cellulose plastics nes	973	674	3458	2617
4235945	Cellulose plastics scrap+waste	5	25	4	14
4136363	Cephalosporin+derivs,bulk	50	10	2912	3938
4059722	Cerium chloride	0	0	0	0
4059729	Cerium compounds	6	1	24	6
4059723	Cerium naphthenate	0	0	0	0
4059721	Cerium oxide	27	25	169	210
4053242	Cermets radio-active	0	0	0	0
4115215	Cetrimonium bromide,bulk	34	21	126	86
4079533	Cetyl alcohol	116	165	257	373
4109921	Cetyl sulphate	25	0	47	0
4079950	Chloral hydrate,in bulk	5	7	11	23
4188961	Chloramben,formulated herb	0	108	0	441
4136477	Chloramphenicol,in bulk	37	18	1790	755
4188222	Chlorate base formulated	18	0	55	0
4188262	Chlorate-borate mix formulated	229	220	251	285
4069882	Chlordane	43	27	320	185
4127726	Chlordiazepoxide,in bulk	1	1	377	290
4116451	Chlordimeform+its HCl	3	4	1	115
4189517	Chlordimeform,formulated	10	0	24	0
4098025	Chlorendic acid	218	210	565	627

SC code	Imported product	Volume (in mt) 1981	Volume (in mt) 1982	Value (in $000) 1981	Value (in $000) 1982
4109942	Chlorfenvinphos,technical	42	0	349	0
4116445	Chlorhexidine,in bulk	116	113	652	816
4051039	Chlorides of non-metals	622	599	365	702
4081590	Chlorinated phenol derivatives	340	313	553	608
4239922	Chlorinated rubber	295	292	1114	1131
4000310	Chlorine	24260	21439	3498	3034
4115945	Chloroacetanilide (m,o,p)	297	599	2176	2963
4093215	Chloroacetic acid	268	140	268	136
4093290	Chloroacetic acid derivatives	1	8	1	6
4093245	Chloroacetic acid esters	2	0	2	0
4093225	Chloroacetic acid salts	0	0	0	0
4095843	Chlorobenzoic acid	10	2	1	0
4065924	Chlorodifluoromethane	139	210	333	485
4065949	Chlorofluoro-hydrocarbons	20	119	85	262
4065939	Chlorofluoroethanes nes	493	472	1838	1925
4235557	Chlorofluoroethylene resin	62	83	358	258
4065929	Chlorofluoromethanes nes	10	23	14	39
4064210	Chloroform	3070	2754	1537	1478
4069945	Chloropicrin	83	0	202	0
4184043	Chloropicrin,formulated pest	95	0	248	0
4127630	Chloroquine,in bulk	4	3	81	25
4019931	Chlorosulphonic acid	2060	1840	801	822
4185832	Chlorothalonil,formulated	311	283	1869	1832
4129131	Chlorothiazide,in bulk	2	1	44	40
4069874	Chlorotoluenes	37	21	25	16
4065922	Chlorotrifluoromethane	27	18	46	21
4127727	Chlorpheniramine,in bulk	2	12	80	91
4127712	Chlorpromazine,in bulk	1	3	55	229
4129152	Chlorpropamide,in bulk	4	6	100	98
4127613	Chlorprothixene,in bulk	0	5	0	15
4127446	Chlorpyrifos, technical	0	0	0	0
4184066	Chlorpyrifos,formulated pest	186	513	1443	2413
5136455	Chlortetracycline,in bulk	353	273	2282	2236
4188982	Chlorthal dimethyl,formulated	51	19	362	161
4129137	Chlorthalidone,in bulk	2	2	821	434
4079972	Cholesterol	4	2	121	53
4099717	Cholic acid	1	1	3	3
4115115	Choline	19	46	67	93
4115125	Choline chloride	2472	2572	2313	2543
4115190	Choline derivatives	11	15	56	75
4136916	Choline theophyllinate,inorg	20	16	296	221
4023230	Chromic hydroxide	14	1	61	4
4038020	Chromic sulphate	1328	922	1385	952
4038435	Chromium ammonium sulfate	2	3	1	1
4023220	Chromium oxides	1778	1160	5276	3299
4038434	Chromium potassiumsulfate	2	15	1	6
4049649	Chromium salts,inorg acid	9	5	4	1
4038090	Chromiun sulphates nes	504	188	346	162

SC code	Imported product	Volume (in mt) 1981	1982	Value (in $000) 1981	1982
4133012	Chymotrypsin,in bulk	11	0	6	0
4083145	Cineole	2	11	5	23
4085953	Cinnamaldehyde	32	13	51	34
4095850	Cinnamic acid	1	3	6	17
4079982	Cinnamyl alcohol	11	6	14	8
4099115	Citric acid	2500	2744	4652	5052
4099189	Citric acid derivatives	14	52	39	96
4099149	Citric acid esters nes	0	0	0	0
4099139	Citric acid salts nes	293	146	477	267
4079540	Citronellol	40	35	50	53
4095750	Citronellyl benzoate	0	0	0	0
4127761	Clidinium bromide,in bulk	2	5	107	79
4127646	Clopenthixol,in bulk	0	9	0	1
4129144	Clorexolone,in bulk	0	0	0	0
4136353	Cloxacillin,in bulk	18	70	2365	2045
4053245	Cobalt 60	1	10	6	25
4090624	Cobalt acetate	35	8	171	94
4043723	Cobalt carbonate	71	99	921	482
4029936	Cobalt hydroxide	14	29	291	267
4096020	Cobalt linoleate	0	0	0	0
4298721	Cobalt naphthenate	1	4	1	4
4029935	Cobalt oxide	6	26	238	29
4029937	Cobalt peroxide	0	0	0	0
4069659	Cobalt salts,inorgan acid	1	26	2	21
4038424	Cobalt sulphate	39	18	450	166
5135390	Cocaine derivatives nes	0	0	0	0
4135320	Cocaine hydrochloride	33	44	27	37
4135336	Cocaine nitrate,in bulk	0	0	0	0
4135340	Cocaine sulphate,in bulk	0	0	0	0
4135220	Cocaine,in bulk	0	0	0	0
4135130	Codeine citrate,in bulk	0	0	0	0
4155190	Codeine derivatives nes	3	0	47	0
4135135	Codeine hydrobromide	0	0	0	0
4135140	Codeine hydrochloride	0	0	0	0
4135145	Codeine methobromide,bulk	0	0	0	0
4135150	Codeine phosphate,in bulk	8	9	4581	4157
4135155	Codeine sulfate,in bulk	143	33	26	8
4135120	Codeine,in bulk	2	220	1	40
4136615	Colistin,in bulk	0	0	0	0
4226090	Compounded/semiprocessed	748	1395	1855	3671
4235490	Copolymerization resins	5172	5607	12319	14071
4090625	Copper acetate	5	7	46	27
4043724	Copper carbonate	48	21	120	72
4033626	Copper chlorides	18	312	29	53
4049923	Copper chrome arsenate	6	4	3	3
4044921	Copper cyanide	127	50	152	202
4121241	Copper dimethyldithiocarbamate	0	0	0	0
4028130	Copper hydroxides	5	5	0	11

SC code	Imported product	Volume (in mt) 1981	Volume (in mt) 1982	Value (in $000) 1981	Value (in $000) 1982
4298722	Copper naphthenate	70	138	92	264
4028120	Copper oxides	277	282	799	756
4059837	Copper phosphide	19	15	21	27
4049669	Copper salts of inorg acids	5	2	1	17
4094231	Copper stearate	12	5	17	31
4037910	Copper sulphates	339	4537	329	2751
4156914	Cordite	2	0	2	0
4132031	Cortisone,in bulk	2	7	51	49
4127913	Coumarin	18	26	226	350
4235110	Coumarone-indene resins	784	581	833	518
4080390	Cresol derivatives nes	44	79	66	123
4080370	Cresol,mixed isomers of	239	368	516	686
4099735	Cresotic acid	0	8	0	17
4080410	Cresylic acid	422	211	563	298
4115970	Crotamiton,in bulk	0	0	0	0
4085932	Crotonaldehyde	84	0	65	0
4090416	Crotonic acid	22	31	30	48
4063366	Cumene	4	37	0	26
4083271	Cumene hydroperoxide	152	86	164	105
4139931	Cupric acetoarsenite	0	1	0	3
4188832	Cyanazine,formulated herb	718	82	3590	411
4059982	Cyanogen + its halogen	1	0	3	0
4127422	Cyanuric acid, normal	95	33	157	69
4095869	Cyc o-terpenic acids	67	68	89	82
4079979	Cyc o-terpenic alcohols	23	3	75	7
4088938	Cyc o-terpenic ketones	1	5	23	59
4098029	Cyc o-terpenic polyacids	1	10	0	0
4112679	Cyc terpenic amines	108	227	489	944
4085949	Cycl o-terpenic aldehydes	5	5	8	0
4083149	Cycl o-terpenic ethers	1	16	2	23
4099933	Cyclandelate, in bulk	1	1	23	16
4063349	Cyclanes + cyclenes nes	115	56	253	157
4115979	Cyclic amides nes	401	361	12566	27221
4114929	Cyclic amino alcohols+dervs	23	3	3301	2477
4085919	Cyclic polymers aldehydes	2	3	6	12
4239927	Cyclised rubber resins	42	18	80	68
4127633	Cyclizine,in bulk	0	0	0	1
4185650	Cycloate formulated pesticides	40	91	385	415
4121337	Cycloate,technical	0	0	0	0
4063340	Cyclohexane	37	20	49	18
4095861	Cyclohexanecarboxylic acod	0	4	0	0
4088930	Cyclohexanone	401	289	928	971
4126333	Cyclohexbenzothiazole sulfamide	204	166	972	843
4063341	Cyclohexene	7	1	6	2
4063347	Cyclopentane	5	6	4	3
4095862	Cyclopentenylacetic acid	0	1	0	2
4127467	Cyclophosphamide,in bulk	1	11	19	24
4063345	Cyclopropane in bulk	4	18	3	24

SC code	Imported product	Volume (in mt)		Value (in $000)	
		1981	1982	1981	1982
4136463	Cycloserine,in bulk	5	0	13	0
4063359	Cycloterpenes nes	118	96	135	98
4129142	Cyclothiazide,in bulk	0	0	0	0
4189480	Cyhexatin,formulated acarnicide	37	0	1327	0
4127660	Cyproheptadine,in bulk	2	4	127	220
4122045	Cysteine	22	14	653	537
4127753	Cytosine arabinoside,bulk	4	0	38	47
4183020	DDT dusts	0	0	0	0
4183021	DDT emulsifiable solution	0	0	0	0
4183022	DDT wettable powder	0	0	0	0
4068710	DDT, technical	1	0	1	0
4183090	DDT,formulated pesticide	0	7	0	16
4188963	Dalapon,formulated herbicide	93	231	743	1720
4127676	Debrisoquine,in bulk	1	1	103	13
4063342	Decahydronaphthalene	0	1	0	1
4063326	Decane	4	12	3	17
4079521	Decyl alcohol	2546	1987	3458	2534
4099741	Dehydrocholic acid, bulk	23	1	104	21
4136540	Demethylchlortetracycline	0	0	0	0
4099721	Deoxycholic acid	0	0	0	0
4069989	Derivatives hydrocarbons	166	94	323	187
4127733	Desipramine,in bulk	6	0	113	54
4132043	Desoxycorticosterone	0	0	0	0
4135850	Desoxyephedrine HCl,bulk	0	0	0	0
4053226	Deuterium	3	2	9	5
4053220	Deuterium oxide	54	3	29	467
4132035	Dexamethasone,in bulk	4	6	244	241
4293220	Dextrin	2605	1669	1926	1335
4293230	Dextrin,dextrin non-adhesive	697	1487	481	1209
4097944	Di(butoxyethyl)phthalate	0	0	0	0
4122983	Di(hydroxydiphenyl)sulfonate	3	0	10	0
4098056	Di(n-octyl,ndecyl)adipate	0	0	0	0
4097933	Di(octyldecyl)phthalate	0	1	0	1
4124575	Di(phenylmercury)dodecsucinate	0	0	0	0
4109973	Di-n-propyl peroxydicarbonate	25	23	412	404
4116443	Di-o-tolylguanidine	10	23	48	94
4122924	Di-o-tolylthiourea	0	0	0	0
4109964	Di-sec-butyl peroxydicarbonate	30	18	452	279
4083261	Di-tert-butyl peroxide	62	79	235	262
4088952	Diacetone alcohol	986	861	996	915
4099752	Diacetone ketogluconic	0	0	0	0
4088927	Diacetyl	5	4	10	9
4135254	Diacetylmorphine,in bulk	0	1	0	0
4185651	Diallate,formulated pesticide	240	0	349	0
4121336	Diallate,technical	0	0	0	0
4097930	Diallyl phthalate	61	26	198	127
4165822	Diammonium phosphate(DAP)	121631	109844	30019	30955
4097940	Diamyl phthalate	0	0	0	0

SC code	Imported product	Volume (in mt)		Value (in $000)	
		1981	1982	1981	1982
4114951	Diatrizoate sodium,bulk	12	5	528	200
4127722	Diazepam,in bulk	2	4	906	794
4127443	Diazinon, technical	124	115	1103	1036
4184053	Diazinon,formulated pesticide	7	0	59	0
4117729	Diazo-compounds nes	38	43	781	825
4117711	Diazoaminobenzene	1	0	2	0
4127644	Diazoxide,in bulk	0	0	0	0
4127767	Dibucaine hydrochloride	4	2	54	40
4083125	Dibutyl ether	7	6	1	1
4098063	Dibutyl fumarate	0	6	0	14
4098041	Dibutyl maleate	0	0	0	0
4097922	Dibutyl phthalate	118	45	159	44
4098061	Dibutyl sebacate	22	18	27	19
4112524	Dibutylamines	89	45	247	124
4121239	Dibutyldithiocarbamates	3	4	11	22
4112647	Dibutylp-phenylenediamine	0	0	0	0
4040630	Dicalcium phosphate	9007	5528	4305	3505
4188962	Dicamba,formulated herbicidie	473	1220	3878	10095
4097937	Dicapryl phthalate	517	322	660	348
4188966	Dichlobenil,formulated herb	43	22	109	59
4069863	Dichlordiphenyldichlorethylene	0	0	0	0
4083133	Dichlorethyl ether	0	1	0	1
4096082	Dichloroacetyl chloride	0	0	0	0
4065921	Dichlorodifluoromethane	293	339	625	772
4115974	Dichlorodimethylhydantoin	2	22	6	205
4127424	Dichloroisocyanuric acid	36	3	107	8
4083135	Dichloroisopropyl ether	0	2	0	0
4083134	Dichloromethyl ether	0	0	0	0
4189155	Dichloropropene,formulated	1104	1101	1352	1716
4065932	Dichlorotetrafluoroethane	34	1	80	2
4184112	Dichlorvos,formulated pest	22	8	143	10
4109943	Dichlorvos,technical	1	0	4	0
4136354	Dicloxacillin,in bulk	8	3	39	18
4189475	Dicofol,formulated acarnicide	24	17	49	93
4083286	Dicumyl peroxide	239	261	1708	2045
4117424	Dicyandiamide	22	10	36	1
4097935	Dicyclohexyl phthalate	51	19	136	48
4114922	Dicyclomine HCl, in bulk	7	4	66	34
4063346	Dicyclopentadiene	22	27	18	19
4083725	Dieldrin	0	0	0	0
4189537	Dieldrin,formulated insecticide	0	0	0	0
4131089	Dietary supplements nes	13	14	221	251
4090663	Dieth glycol butylether acetate	63	22	69	27
4090662	Dieth glycol monethether acet	5	14	51	22
4083230	Dieth glycol monobutether	356	693	428	894
4083231	Dieth glycol monoethether	57	71	61	73
4083232	Dieth glycol monometether	70	32	82	41
4113430	Diethanolamine	1747	2258	2029	2570

SC code	Imported product	Volume (in mt)		Value (in $000)	
		1981	1982	1981	1982
4109960	Diethyl carbonate	34	32	63	62
4097943	Diethyl glycol phthalate	0	1	0	1
4098047	Diethyl oxalate	6	4	22	5
4097921	Diethyl phthalate	119	64	140	104
4109917	Diethyl sulphate	9	9	1	14
4125964	Diethylaluminum chloride	243	223	359	302
4112522	Diethylamine	234	133	443	286
4114971	Diethylaminoethanol	0	0	0	0
4112544	Diethylaniline	31	1	102	0
4121259	Diethyldithiocarbamates	1	1	21	21
4083212	Diethylene glycol	129	336	126	213
4112613	Diethylenetriamine	586	515	1816	1707
4117870	Diethylhydroxylamine	83	71	425	440
4088921	Diethylketone	1	4	1	0
4109963	Diethylpyrocarbonate	0	2	0	5
4109950	Diethylstilbestrol diphosph	133	38	235	83
4081327	Diethylstilbestrol, bulk	10	0	8	0
4127526	Difenzoquat, technical	426	607	7003	8988
4069830	Difluoroethane	27	28	110	104
4069845	Difluoroethylene	0	0	0	0
4134035	Digitoxin,in bulk	1	0	2	0
4095041	Diglycol laurate	0	0	0	0
4134045	Digoxin,in bulk	1	1	257	269
4097941	Dihexyl phthalate	0	0	0	0
4135170	Dihydrocodeinone,in bulk	319	141	93	38
4135927	Dihydroergotamine,in bulk	441	1	5	5071
4136425	Dihydrostreptomycin,bulk	20	7	1252	443
4088925	Diisobutyl ketone	93	62	77	60
4060724	Diisobutylene	133	42	119	41
4097926	Diisodecyl phthalate	368	101	467	125
4097924	Diisooctyl phthalate	56	0	72	0
4083123	Diisopropyl ether	0	1	0	1
4083287	Diisopropylbenzene hydrop	34	15	51	52
4112646	Diisopropylphenylenediamine	0	0	0	0
4135922	Dimenhydrinate,in bulk	6	4	192	132
4127643	Dimethindene,in bulk	0	0	0	0
4132670	Dimethisterone,in bulk	0	0	0	0
4184063	Dimethoate,formulated pest	4	2	12	7
4122951	Dimethoate,technical	39	13	119	69
4127616	Dimethoxanate,in bulk	2	2	63	86
4097932	Dimethoxy ethyl phthalate	13	14	33	14
4098046	Dimethyl oxalate	0	0	0	0
4097920	Dimethyl phthalate	119	107	175	149
4109920	Dimethyl sulphate	268	278	292	316
4097927	Dimethyl terephthalate	37965	9365	34814	8610
4112521	Dimethylamine	907	1205	1262	1676
4112523	Dimethylamine sulphate	21	4	64	9
4121249	Dimethyldithiocarbamates	4	7	41	1

SC code	Imported product	Volume (in mt)		Value (in $000)	
		1981	1982	1981	1982
4117850	Dimethylhydrazine	0	0	0	0
4088920	Dimethylketone	1467	640	611	415
4112412	Dimethylnitrosamine	2	28	4	43
4185630	Dimetilan,formulated pest	0	0	0	0
4127822	Dinitrosopentameth tamine	6	11	18	35
4069964	Dinitrotoluol	84	68	229	200
4188971	Dinoseb,formulated herbicide	174	49	429	87
4098057	Dioctyl adipate	12	0	23	0
4098053	Dioctyl azelate	8	7	12	25
4099932	Dioctyl diglycollate	0	0	0	0
4098062	Dioctyl sebacate	48	32	67	60
4082131	Dioxane	246	162	546	418
4127487	Dipentamethylenethiuram	7	0	67	0
4063353	Dipentene	22	40	24	38
4235527	Dipentene resins	24	17	34	24
4188983	Diphenamid,formulated herb	65	64	558	306
4114912	Diphenhydramine,in bulk	3	23	141	158
4095826	Diphenolic acid	7	3	44	19
4081359	Diphenols+polyphenols nes	765	199	1059	702
4109955	Diphenyl phosphate	22	41	57	113
4112652	Diphenyl-p-phenylenediami	0	0	0	0
4112550	Diphenylamine	1511	1548	3619	3855
4112552	Diphenylamine derivatives	375	228	1555	1044
4115975	Diphenylhydantoin,bulk	11	20	258	377
4118215	Diphenylmethane 4,4-diiso	876	8451	2220	22274
4127465	Diphenylpyraline,in bulk	1	3	10	2
4122922	Diphenylthiourea	5	5	23	30
4083243	Dipropylene glycol	9	38	19	50
4188974	Diquat,formulated herbici	0	119	0	498
4059981	Distilled water,in bulk	1	11	0	3
4126342	Dithiobis(benzothiazole)	164	79	671	294
4121279	Dithiocarbamates nes	6	13	16	29
4188851	Diuron,formulated herbicide	30	23	187	127
4083117	Divinyl ether	0	1	0	2
4063361	Divinylbenzene	122	106	377	390
4098051	Dodecenyl succinic anhydride	36	37	51	76
4122023	Dodecyl mercaptan	304	160	537	322
4184131	Dodine,formulated pesticide	24	53	165	369
4116455	Dodine,technical	0	0	0	0
4115225	Domiphen bromide,bulk	1	1	2	3
4127731	Doxepin,in bulk	1	2	470	603
4136542	Doxycycline,in bulk	32	1	735	452
4127445	Doxylamine succinate,bulk	7	9	86	12
4127771	Droperidol,in bulk	1	2	90	48
4135917	Dyphylline,in bulk	0	0	0	0
4114973	Edetic acid+derivatives	1235	1114	1182	1055
4083726	Endrin	0	0	0	0
4133089	Enzymes,in bulk	661	367	3781	3142

SC code	Imported product	Volume (in mt)		Value (in $000)	
		1981	1982	1981	1982
4133025	Enzymes,malt,in bulk	3	5	13	3
4133019	Enzymes,pancreatic,bulk	2	4	18	48
4133045	Enzymes,pectic,in bulk	7	21	181	260
4135936	Ephedrine,in bulk	10	7	506	344
4083721	Epichlorohydrin	1879	378	3264	750
4132684	Epinephrine,in bulk	0	1	9	15
4232010	Epoxy resins	8600	9936	22105	28873
4185653	Eptam,formulated pesticide	239	728	906	3088
4135933	Ergometrine,in bulk	0	200	0	8
4135943	Ergotamine tartrate,bulk	1021	3	2900	3680
4135934	Erogonovine,in bulk	0	2	0	3
4136443	Erythromycin,in bulk	25	21	2901	2705
4235840	Ester gums	1033	464	1849	867
4132652	Estriol,in bulk	0	0	0	0
4090661	Eth glycol diacetate	137	73	126	81
4090665	Eth glycol mmethyethracetate	44	58	46	56
4090660	Eth glycol monethethracetate	3725	3091	4706	4353
4083227	Eth glycol monmethylether	154	176	180	184
4083226	Eth glycol monoethylether	639	525	610	499
4099751	Ethacrynic acid, in bulk	7	2	14	7
4114915	Ethambutol,in bulk	7	2	20	7
4079947	Ethchlorvynol, in bulk	1	7	79	71
4083239	Ether alcohol nes	1146	1942	1809	2571
4083259	Ether phenols+ether-alc-per	633	486	953	783
4184071	Ethion,formulated pestcide	1	0	2	0
4127412	Ethionamide,in bulk	0	0	0	0
4127620	Ethoheptazine,in bulk	1	6	12	1
4115976	Ethotoin,in bulk	0	0	0	0
4090322	Ethoxy ethyl acrylate	175	2	241	7
4083215	Ethoxy triglycol	7	0	0	0
4127512	Ethoxyquin, technical	193	154	855	793
4129134	Ethoxyzolamide,in bulk	0	0	0	0
4090646	Ethyl acetate	5049	6169	4589	5459
4090323	Ethyl acrylate	5717	4776	7753	6699
4079921	Ethyl alcohol	476	293	405	250
4114970	Ethyl aminobenzoate,bulk	9	11	26	46
4095741	Ethyl benzoate	0	5	0	0
4095815	Ethyl butyric acid	87	0	66	0
4115932	Ethyl carbamate	37	38	103	75
4238933	Ethyl cellulose	121	99	988	1037
4069827	Ethyl chloride	936	76	526	30
4099143	Ethyl citrate	1	4	3	8
5083115	Ethyl ether, in bulk	737	817	1001	1030
4090234	Ethyl formate	45	52	17	20
4079541	Ethyl hexanediol	9	5	14	8
4090666	Ethyl hexyl acetate	63	60	93	138
4109915	Ethyl hydrogen sulphate	0	0	0	0
4077820	Ethyl isohexanol	40	82	30	63

SC code	Imported product	Volume (in mt)		Value (in $000)	
		1981	1982	1981	1982
4098231	Ethyl lactate	3	11	0	1
4098042	Ethyl maleate	2	9	2	13
4122033	Ethyl mercaptan	177	379	397	922
4186112	Ethyl mercury salts,formulated	0	0	0	0
4083127	Ethyl methyl ether	0	2	0	0
4117860	Ethyl methyl ketoxime	268	166	540	322
4109934	Ethyl nitrite	0	0	0	0
4099926	Ethyl parahydroxybenzoate	9	4	1	15
4099915	Ethyl salicylate	3	0	1	0
4109970	Ethyl silicate	92	127	272	363
4098431	Ethyl tartrate	8	0	1	0
4085977	Ethyl vanillin	11	9	218	188
4125963	Ethylaluminum sesquichloride	1	0	10	0
4063362	Ethylbenzene	40	80	61	1
4063332	Ethylene	157	99	61	41
4064010	Ethylene bromide	6860	6551	4703	4630
4117520	Ethylene cyanohydrin	61	14	492	121
4069823	Ethylene dichloride	138	63	117	29
4109933	Ethylene glycol dinitrate	1	0	2	0
4094243	Ethylene glycol distearate	76	58	114	74
4076110	Ethylene glycol, mono	3611	8311	2507	3999
4083720	Ethylene oxide	90	792	132	848
4127331	Ethylene thiourea	65	42	214	112
4225080	Ethylene-propylene rubber	4040	4666	8995	11353
4234825	Ethylene-vinyl acetate coply	4595	4797	7810	8177
4112612	Ethylenediamine	191	120	564	366
4109954	Ethylhexyl phosphate	5	6	17	16
4116446	Ethylidene-para-toluidine	0	0	0	0
4135232	Ethylmorphine,in bulk	21	0	6	0
4125431	Ethyltrichlorosilane	0	11	0	3
4079590	Fatty alcohols nes,	5234	2886	6994	4187
4117713	Fenaminosulf,technical	0	0	0	0
4184052	Fenitrothion,formulated pest	331	515	2175	3355
4109971	Fenitrothion,technical	472	493	3635	3388
4184056	Fensulfothion,formulated	38	26	109	188
4127466	Fentanyl,in bulk	1	2	9	7
4125984	Fentin acetate,technical	2	0	4	0
4188854	Fenuron,formulated herbicide	0	0	0	0
4121244	Ferbam, technical	4	0	9	0
4185720	Ferbam,formulated pesticide	2	0	8	0
4099124	Ferric ammonium citrate	10	9	40	23
4049677	Ferric hypophosphite	2	1	4	2
4049671	Ferric phosphate	80	46	130	89
4049672	Ferric pyrophosphate	11	1	2	2
4038422	Ferric sulphate	2249	3512	354	402
4098072	Ferrous fumarate	66	78	190	307
4099761	Ferrous gluconate	19	21	89	79
4169989	Fertilizers+fertilizer matrl	33280	20208	10875	7662

SC code	Imported product	Volume (in mt)		Value (in $000)	
		1981	1982	1981	1982
4169945	Fertilizers,vegetable	1301	728	654	869
4132044	Fludrocortisone,in bulk	0	0	0	0
4132042	Fluocinolone acetonide	0	0	405	282
4051059	Fluorides of non-metals	4	15	11	67
4031990	Fluorides+complex fluorin	1928	1610	1924	1941
4004920	Fluorine	5	4	3	4
4235547	Fluoroethylene resins	288	294	3258	3787
4031931	Fluorosilicate metal salt	1849	1393	510	404
4132681	Fluoxymesterone,in bulk	1	0	22	23
4127680	Fluphenazine,in bulk	12	4	860	807
4132034	Flurandrenolone,in bulk	4	6	244	241
4127741	Flurazepam,in bulk	6	3	614	815
4131026	Folic acid,in bulk	6	4	400	499
4084520	Formaldehyde	1951	1059	655	396
4090215	Formic acid	820	621	534	453
4090289	Formic acid derivatives	2	1	3	0
4090249	Formic acid esters nes	10	9	4	0
4090229	Formic acid salts nes	0	4	0	0
4096510	Fumaric acid	725	587	923	735
4189190	Fumigants,formulated,nes	1373	1196	3135	2943
4186119	Fungicide mercurial,seed	6	15	2	49
4185889	Fungicide nes,exc seed tr	1002	829	4457	6949
4185829	Fungicide,cupreous,exc seed tr	37	265	28	677
4185819	Fungicide,mercurial	24	14	323	216
4186189	Fungicide,seed treatment	333	504	965	1524
4127755	Furazolidine,in bulk	109	78	1169	732
4127323	Furfural	740	324	936	505
4127321	Furfuryl alcohol	1257	861	2143	1606
4232940	Furfuryl resins	106	57	285	110
4129136	Furosemide,in bulk	5	4	1002	635
4156973	Fuses,blasting type	0	0	293	906
4059739	Gadolinium compds	0	8	0	38
4059732	Gadolinium oxide	0	1	0	0
4059731	Gadolinium oxide,reclaimed	0	1	0	0
4099732	Gallic acid	3	1	7	4
4290720	Gasoline antioxidants	477	287	999	578
4290725	Gasoline inhibitors	85	114	151	296
4239940	Gelatin hardened resins	36	35	134	42
4294610	Gelatin, inedible	356	299	3439	3630
4095747	Geranyl benzoate	2	2	0	2
4127917	Gibberellic acid	2	0	53	0
4099712	Gluconic acid	161	122	149	134
4127447	Gluconolactone	44	52	107	144
4211930	Glue,casein base	92	119	205	205
4114961	Glutamic acid	11	9	26	24
4116425	Glutethimide,in bulk	1	2	44	6
4129150	Glyburide,in bulk	11	33	348	349
4294810	Glycerin,crude	3145	2396	3717	2885

SC code	Imported product	Volume (in mt) 1981	Volume (in mt) 1982	Value (in $000) 1981	Value (in $000) 1982
4294910	Glycerin,refined	441	523	862	1097
4090652	Glycerol acetates	741	753	1481	1631
4083216	Glycerol guaiacolate	19	8	106	91
4114964	Glycine+glycine derivatives	140	375	1454	4425
4094240	Glycol stearate	34	4	55	8
4134090	Glycosides+derivatives	69	5	180	260
4085923	Glyoxal	909	806	1079	980
4059614	Gold amalgams	0	9	0	1
4059613	Gold chloride	20	3	3	0
4059619	Gold compounds,org,inorganic	1515	370	570	179
4136620	Gramicidins,in bulk	9	1	43	40
4083247	Guaiacol	7	8	154	59
4127472	Guanethidine,in bulk	0	1	40	36
4116440	Guanidine	18	22	58	68
4169931	Guano	19	0	1	0
2179930	Guar gums	1656	1382	3874	3227
4150910	Gunpowder+similar powder	316	180	2249	1430
4051079	Halogen compounds ofnonme	9	6	36	42
4069879	Halogen deriv of aromatic	2	599	6	453
4069889	Halogen deriv of hydrocarbon	415	284	1524	982
4069839	Halogen deriv of sat acyclic	146	82	399	157
4069859	Halogen deriv of unsat	237	110	194	50
4081869	Halogenated deriv phenol	12	36	16	96
4127763	Haloperidol,in bulk	20	1	356	639
4085971	Heliotropin	46	23	59	57
4239945	Heparin,in bulk	5	2	41	224
4069881	Heptachlor, technical	0	0	0	0
4184041	Heptachlor,formulated pest	8	2	17	11
4063321	Heptane	204	401	66	133
4063337	Heptene mixed isomers	0	0	0	0
4063336	Heptene,exc mixed isomers	0	4	0	4
4188839	Herbicides based on triazine	367	285	3324	7841
4188859	Herbicides methylurea bas	14	0	98	0
4188819	Herbicides picolinic base	11	0	28	0
4188990	Herbicides,formulated nes	8265	7357	34169	38441
4136357	Hetacillin,in bulk	3	0	17	0
4127790	Heterocyclic cmpds complexs	0	0	0	0
4127590	Heterocyclic cmpds,complexs	435	240	3260	2076
4127990	Heterocyclic compds nes	791	991	5247	5993
4127390	Heterocyclic cmpds,5 mem rings	536	377	24497	36225
4127490	Heterocyclic cmpds,6 mem rings	551	843	3059	4350
4184042	Hexachlor,formulated pest	3	1	68	2
4069861	Hexachlorobenzene	7	68	13	49
4069880	Hexachlorocyclohexane	143	106	1736	1111
4081525	Hexachlorophene,in bulk	7	8	251	250
4112670	Hexahydroaniline	612	307	1258	502
4079971	Hexahydrophenol	30	43	40	74
4125441	Hexamethyldisiloxane	1	11	5	4

SC code	Imported product	Volume (in mt) 1981	Volume (in mt) 1982	Value (in $000) 1981	Value (in $000) 1982
4112410	Hexamethylenediamine	1377	18	3593	34
4118221	Hexamethylenediisocyanate	46	18	96	47
4116310	Hexamethylenetetramine	204	186	214	135
4063320	Hexane	5002	2032	2741	158
4079932	Hexanol/hexyl alcohol	20	77	21	115
4109924	Hexyl sulphate	6	0	1	0
4079951	Hexylene glycol	44	24	115	41
4135946	Homatropine,in bulk	556	31	3	4
4132669	Hormones anabolic,in bulk	0	0	68	0
4132612	Hormones ant pituitary	6	5	100	216
4132659	Hormones estrogenic,bulk	2	10	131	271
4132615	Hormones pancreatic,bulk	0	2	639	378
4132613	Hormones post pituitary	5	3	211	148
4132679	Hormones progestational	116	1	975	747
4132614	Hormones thyroid,in bulk	3	0	32	2
4132090	Hormones,adrenal cortical	2	1	2122	2026
4132720	Hormones,comb,oral contraceptv	0	0	0	0
4132790	Hormones,combos,in bulk	7	5	20	37
4132689	Hormones,natural or synthetic	0	1	28	140
4115973	Hydantoin	7	5	22	17
4127674	Hydralazine,in bulk	1	2	965	1359
4029970	Hydrazine	64	1	135	4
4029971	Hydrazine hydrate	272	268	551	490
4029979	Hydrazine inorganic salts	2	21	0	52
4029973	Hydrazine monohydrobromide	4	0	12	0
4117859	Hydrazine organic derivatives	30	26	298	89
4059859	Hydrides nes	7	1	6	1
4019933	Hydrochloric acid	17262	16735	1146	1166
4129140	Hydrochlorothiazide,bulk	14	21	1601	1236
4132033	Hydrocortisone phosphate	0	0	11	0
4132032	Hydrocortisone,in bulk	0	0	2	0
4129146	Hydroflumethiazide,bulk	0	2	0	15
4019934	Hydrofluoric acid	513	441	397	496
4004923	Hydrogen	374	398	134	119
4059815	Hydrogen peroxide	11469	15517	8397	10256
4059831	Hydrogen phosphide	1	11	1	14
4019935	Hydrogen sulphide	1342	1453	239	454
4135256	Hydromorphone,in bulk	0	0	0	0
4081350	Hydroquinone	120	63	453	236
4083241	Hydroquinone monethylether	8	0	53	0
4123325	Hydroxy nitrobenzenearson	30	29	227	391
4099713	Hydroxyacetic acid	178	214	190	218
4127632	Hydroxychloroquine, bulk	4	5	38	33
4114926	Hydroxyeth dieth triamine	1	3	3	9
4238934	Hydroxyethyl cellulose	999	708	4519	4073
4090423	Hydroxyethyl methacrylate	8	39	12	89
4029980	Hydroxylamine	1	5	2	20
4029989	Hydroxylamine inorganic	8	11	48	29

SC code	Imported product	Volume (in mt)		Value (in $000)	
		1981	1982	1981	1982
4117879	Hydroxylamine organic dervs	91	33	1077	444
4099736	Hydroxynaphthoic acid	21	71	117	225
4088957	Hydroxyoctyloxybenzophenn	165	122	2711	2128
4090424	Hydroxypropylmethacrylate	84	69	179	145
4127627	Hydroxyzine,in bulk	1	9	185	77
4019946	Hypophosphorus acid	36	11	13	16
4156972	Igniters+detonators,blast	0	0	279	448
4116439	Imide function comppounds	6	15	277	744
4116469	Imine function compounds	34	14	361	295
4127735	Imipramine,in bulk	1	2	308	486
4019949	Inorganic acids nonmetals	5051	3986	3699	2246
4059989	Inorganic chemicals nes	168	109	667	459
4079970	Inositol	7	7	141	160
4189849	Insect growth regulators	11	92	23	230
4189690	Insect repellents,formulated	64	31	295	124
4189590	Insecticides,formulated	3349	1551	10519	6939
4133055	Invertase enzyme	0	0	0	0
4051060	Iodides of non-metals	25	27	115	123
4000810	Iodine	181	112	2759	1786
4051030	Iodine chlorides	4	3	14	8
4115950	Iodipamide,in bulk	31	4	132	31
4127743	Iodochlorhydroxyquin,bulk	1	1	43	11
4232610	Ion exchange resins	1758	2386	7466	12423
4088932	Ionone	5	4	8	9
4188984	Ioxynil,formulated herbicide	22	22	147	134
3999464	Irish moss extract	88	97	875	942
4043725	Iron carbonate	124	124	60	22
4033627	Iron chloride	1000	651	425	343
4098226	Iron lactate	0	0	0	0
4024010	Iron oxides nat or synthetic	8411	6181	5910	5469
4059835	Iron phosphide	0	0	0	0
4049679	Iron salts,inorganic acids	40	5	26	1
4049675	Iron sulphide	2	0	0	0
4122940	Iso-octyl mercaptoacetate	1	7	2	4
4127911	Isoascorbic acid	11	17	104	176
4127912	Isoascorbic acid sodium salts	514	522	2868	3098
4079977	Isoborneol	0	0	0	0
4122976	Isobornylthiocyanoacetate	0	0	0	0
4060723	Isobutene	191	135	168	104
4094241	Isocetyl stearate	0	20	0	48
4118290	Isocyanates,nes	2101	1170	5253	5229
4079524	Isodecanol	2676	2497	2788	2266
4127485	Isoniazide,in bulk	4	1	21	6
4127450	Isonicotinic acid	0	2	0	6
4063324	Isooctane	22	31	21	32
4077890	Isooctyl alcohol+isomers	7	8	3	4
4063325	Isopentane	194	216	88	90
4088933	Isophorone	174	97	304	151

SC code	Imported product	Volume (in mt) 1981	Volume (in mt) 1982	Value (in $000) 1981	Value (in $000) 1982
4097110	Isophthalic acid	2040	1368	2357	1630
4061010	Isoprene	1975	1275	2867	2163
4083131	Isopropyl ether	1	0	2	0
4121325	Isopropyl ethylthionocarbamate	0	83	0	443
4096033	Isopropyl myristate	94	93	179	211
4096032	Isopropyl palmitate	152	76	63	147
4122982	Isothiocyanates	6	11	1	4
4053249	Isotopes radioactive	198	257	7227	9070
4053229	Isotopes stable+compounds	28	126	1499	829
4098014	Itaconic acid	761	678	2497	2448
4297030	Ivory black	0	4	0	4
4166930	Kainite	0	0	0	0
4136465	Kanamycins,in bulk	0	10	0	26
4185620	Karbutilate,formulated pest	0	0	0	0
4114954	Ketamine+ketamine HCl	5	4	66	13
4088985	Ketone+quinone function	151	72	685	396
4185834	Kromad,formulated fungicides	0	0	0	0
4098215	Lactic acid	278	204	399	315
4098289	Lactic acid derivatives	20	1	47	0
4098239	Lactic acid esters nes	0	21	0	51
4098229	Lactic acid salts nes	0	19	0	39
4002526	Lampblack	119	60	150	66
4221090	Latex,synthetic,crude nes	13241	6213	18992	10045
4095015	Lauric acid	0	0	0	0
4095089	Lauric acid derivatives	17	68	27	174
4095059	Lauric acid esters nes	1	2	2	3
4095039	Lauric acid salts nes	5	0	8	0
5095042	Lauroyl peroxide	4	1	38	7
4079535	Lauryl alcohol	281	212	472	394
4090425	Lauryl methacrylate	1136	518	2488	1421
4109925	Lauryl sulphate	53	44	104	39
4090626	Lead acetate	280	32	338	66
4049711	Lead arsenate technical	1	1	3	1
4184020	Lead arsenate, formulated	0	0	0	0
4059872	Lead azide	0	4	0	4
4049924	Lead chlorosilicate	0	0	0	0
4025740	Lead dioxide	48	24	127	69
4031933	Lead fluoborate	10	18	17	28
4098071	Lead fumarate,tetrabasic	0	0	0	0
4096023	Lead linoleate	2	0	0	0
4298723	Lead naphthenate	0	0	0	0
4039130	Lead nitrate	91	273	93	265
4095225	Lead oleate	0	12	0	24
4025720	Lead oxide	898	479	1099	543
4097951	Lead phthalate	205	167	343	321
4049719	Lead salts,inorgan acids	19	4	47	16
4045724	Lead silicates	37	35	61	42
4094224	Lead stearate	34	14	56	26

SC code	Imported product	Volume (in mt)		Value (in $000)	
		1981	1982	1981	1982
4038423	Lead sulphates	243	223	368	338
4025730	Lead tetroxide	418	337	461	326
4115250	Lecithin,in bulk	371	295	755	474
4109957	Leptophos, technical	0	0	0	0
4115964	Lidocaine,in bulk	5	10	61	10
4079537	Linalool	19	41	24	65
4090653	Linalyl acetate	8	16	12	26
4095752	Linalyl benzoate	3	2	0	0
4136445	Lincomycin,in bulk	69	71	9073	10338
4095831	Linoleic acid	128	86	343	236
4188852	Linuron,formulated herbicides	204	276	2102	3053
4059780	Liquid air	5	4	32	24
4043726	Lithium carbonate	2082	779	7174	2935
4033615	Lithium chloride	59	24	76	60
4099126	Lithium citrate	1	1	2	2
4029941	Lithium hydroxide	154	99	635	493
4049729	Lithium salts,inorg acids	32	21	82	55
4188960	Londax,formulated herbicides	0	0	0	0
4114963	Lysine+its hydrochlorides	939	879	3570	3106
4099610	MCP technical	864	1948	3356	6566
4047976	Magnesium aluminate	334	447	410	368
4043727	Magnesium carbonate	79	90	134	174
4033616	Magnesium chloride	1204	727	466	395
4021935	Magnesium hydroxide	22790	15274	3402	2781
4098223	Magnesium lactate	0	0	0	0
4298724	Magnesium naphthenate	0	0	0	0
4021930	Magnesium oxide	2774	3578	3172	3090
4021936	Magnesium peroxide	87	1	11	1
4049739	Magnesium salts,inorg acid	7	15	22	33
4045723	Magnesium silicates	130	101	198	141
4094225	Magnesium stearate	11	8	27	13
4038421	Magnesium sulphate bulk	5090	3787	1187	870
4184051	Malathion,formulated pest	111	58	299	187
4122943	Malathion,technical	102	8	354	34
4098013	Maleic acid	40	35	74	44
4098081	Maleic anhydride	2351	1833	2490	1997
4127433	Maleic hydrazide	63	49	164	270
4099711	Malic acid	280	149	427	218
4098011	Malonic acid	13	22	19	25
4099716	Mandelic acid	0	3	0	0
4185725	Maneb,formulated pesticide	432	477	1460	1654
4121262	Maneb,technical	18	0	48	0
4090627	Manganese acetate	15	0	27	0
4033630	Manganese chloride	0	0	0	0
4029946	Manganese hydroxide	79	29	84	41
4096024	Manganese linoleate	0	0	0	0
4298725	Manganese napthenate	0	0	0	0
4029945	Manganese oxide exc nat	1337	1930	764	1028

SC code	Imported product	Volume (in mt)		Value (in $000)	
		1981	1982	1981	1982
4029947	Manganese peroxide+ dioxides	1951	2137	2143	2596
4049749	Manganese salts,inorg acids	25	3	88	30
4038425	Manganese sulphate	911	544	182	104
4079955	Mannitol	190	208	700	711
4169939	Manure,animal,nes	5144	3783	371	333
4169933	Manure,sheep	1215	352	84	24
4226020	Masterbatches,compounded	1104	2468	2084	4084
4127635	Meclizine,in bulk	4	11	24	33
4115954	Meglumine diatrizoate	0	5	0	7
4127452	Melamine	3980	2721	4033	2957
4230410	Melamine-formaldehyde resin	1623	1450	2800	2563
4184064	Menazon,formulated pesticide	0	0	0	0
4076510	Menthol, natural+synthetic	59	68	801	960
4099911	Menthyl salicylate	0	34	0	27
4083211	Mephenesin, in bulk	3	0	4	0
4127625	Mepivacaine,in bulk	4	6	22	28
4115930	Meprobamate,in bulk	8	12	58	91
4135931	Meralluride,in bulk	0	0	0	0
4122090	Mercaptans nes	1170	804	2863	2016
4126319	Mercaptobenzothiazole derv	51	176	272	783
4126314	Mercaptobenzothiazyl disulphide	30	6	91	25
4124535	Mercaptomerin sodium,bulk	0	0	0	0
4033631	Mercuric chloride	0	0	0	0
4098227	Mercuric lactate	0	0	0	0
4049755	Mercuric sulphide	1	5	0	1
4033624	Mercurous chloride	194	2	9	3
4008110	Mercury	48	52	646	657
4059983	Mercury ammoniated	1	0	3	0
4029950	Mercury oxides	50	15	256	257
4049759	Mercury salts,inorg acids	1	2	3	6
4127715	Mesoridazine,in bulk	0	0	0	0
4132651	Mestranol,in bulk	0	0	12	3
4045030	Meta-sodium silicate	661	705	176	271
4059979	Metal amalgams nes	1	0	5	0
4049929	Metal double+complex salts	3838	346	3170	1150
4047979	Metallic aluminates nes	17	7	77	35
4043739	Metallic carbonates nes	523	440	628	584
4125976	Metallic carbonyl salts	11	1	1	2
4034539	Metallic chlorates nes	34	20	23	17
4033639	Metallic chlorides nes	197	162	1417	1014
4033939	Metallic chlorites nes	44	11	47	6
4047929	Metallic chromates nes	68	56	96	118
4044935	Metallic cyanides complex	425	391	536	460
4044929	Metallic cyanides nes	11	3	16	6
4035629	Metallic dithionites nes	11	0	1	0
4033929	Metallic hypochlorites	32	114	54	189
4047969	Metallic molybdates nes	3	0	15	0
4298790	Metallic naphthenates nes	42	26	39	23

SC code	Imported product	Volume (in mt) 1981	Volume (in mt) 1982	Value (in $000) 1981	Value (in $000) 1982
4039139	Metallic nitrates nes	447	454	609	460
4039129	Metallic nitrites nes	13	58	9	80
4029965	Metallic oxides hydr peroxide	74	42	238	2430
4033649	Metallic oxychlorides nes	125	99	224	172
4043745	Metallic percarbonates	27	1	14	2
4034549	Metallic perchlorates nes	235	360	447	829
4047939	Metallic permanganates	0	0	0	0
4038479	Metallic persulphates nes	50	18	25	9
4049989	Metallic salts of inorg acids	1962	328	1859	706
4045729	Metallic silicates nes	362	456	356	634
4047949	Metallic stannates nes	0	0	0	0
4038429	Metallic sulphates nes	682	647	482	426
4035929	Metallic sulphites nes	4	68	1	34
4035639	Metallic sulphoxylates nes	5	38	7	49
4035939	Metallic thiosulphates	2	9	1	3
4047959	Metallic titanates nes	1	1	16	0
4047919	Metallic tungstates nes	3	1	6	0
4019940	Metaphosphoric acid	569	20	217	11
4114985	Metaraminol bitartrate	8	0	1	0
4186113	Metasol,mercurial fungicide	35	57	106	192
4184132	Metaxon,formulated pesticide	0	0	0	0
4090415	Methacrylic acid	599	652	1197	1356
4090489	Methacrylic acid derivatives	69	29	135	49
4090439	Methacrylic acid esters	2167	2486	5171	7238
4233135	Methacrylic acid resins	2258	2085	4826	4757
4090449	Methacrylic acid salts nes	0	16	0	29
4136544	Methacycline,in bulk	0	0	0	0
4132662	Methandrostenolone,bulk	5	0	71	0
4127622	Methapyrilene,in bulk	0	0	0	0
4114980	Methenamine mandelate,bulk	1	2	3	10
4136355	Methicillin sodium,bulk	0	1	0	10
4127355	Methidathion,technical	30	0	198	0
4122390	Methionine derivatives	102	79	319	228
4122325	Methionine hydroxy analogue	157	230	531	741
4122315	Methionine,in bulk	1785	2195	5694	6324
4127682	Methixene,in bulk	0	0	0	0
4127640	Methotrimeprazine,in bulk	1	1	218	257
4088955	Methoxy-4-methylpentanone	11	6	19	12
4083157	Methoxychlor	11	0	100	0
4189525	Methoxychlor,formulated insect	8	5	50	14
4124545	Methoxyethylmercuryacetate	0	0	0	0
4129145	Methyclothiazide,in bulk	0	9	0	5
4090644	Methyl acetate	2	1	3	3
4115921	Methyl acrylamide	192	133	202	188
4090325	Methyl acrylate	542	566	704	847
4070510	Methyl alcohol	859	429	208	72
4095743	Methyl benzoate	1	2	2	3
4189115	Methyl bromide,formulated	32	71	61	136

SC code	Imported product	Volume (in mt) 1981	Volume (in mt) 1982	Value (in $000) 1981	Value (in $000) 1982
4238930	Methyl cellulose	718	625	3648	3315
4063510	Methyl chloride	3989	4210	1863	2133
4109953	Methyl diphenyl phosphate	102	20	234	49
4088922	Methyl ethyl ketone	11172	8015	10399	6724
4090232	Methyl formate	2896	2981	1928	2010
4189125	Methyl formate,formulated	0	2	0	0
4099922	Methyl gallate	0	0	0	0
4109916	Methyl hydrogen sulphate	0	0	0	0
4088923	Methyl isobutyl ketone	248	251	320	293
4088917	Methyl isopropyl ketone	61	4	48	0
4095043	Methyl laurate	370	362	470	466
4122026	Methyl mercaptan	3	5	16	0
4090426	Methyl methacrylate	17253	12898	22911	18519
4088916	Methyl n-propyl ketone	127	160	190	274
4127444	Methyl nicotinate,in bulk	0	10	0	2
4099925	Methyl p-hydroxybenzoate	43	65	245	436
4127341	Methyl pyrrole acetonitrile	27	29	343	412
4099931	Methyl ricinoleate	0	0	0	0
4099912	Methyl salicylate	111	80	375	243
4129235	Methyl sulphanilylcarbamate	11	0	9	0
4114934	Methyl-p-aminophenol sulphate	9	6	11	6
4112520	Methylamine	1441	665	1766	879
4090667	Methylamyl acetate	0	11	0	1
4123341	Methylarsonic acid+its salts	0	0	14	0
4079976	Methylcyclohexanol	3	3	2	4
4114960	Methyldopa,in bulk	61	69	6735	7609
4069822	Methylene chloride	9202	9206	4347	5216
4112545	Methylenebis(o-chloraniln	71	23	449	144
4083265	Methylethyl ketone peroxide	155	129	510	439
4127464	Methylphenidate,in bulk	3	31	189	242
4127435	Meticlorpindol,in bulk	17	0	247	0
4185835	Metiram,formulated fungicide	314	434	861	1459
4188855	Metobromuron,formulated herb	41	46	293	428
4127451	Metribuzin, technical	0	0	0	0
4188825	Metribuzin,formulated herb	0	0	0	0
4127634	Metronidazole,in bulk	5	5	360	217
4184113	Mevinphos,formulated pest	3	0	23	0
4109989	Mineral acid esters,salts	453	274	2031	1239
4189490	Miticides(acaricides) nes	19	5	173	93
4028710	Molybdenum oxides + hydro	423	193	6517	2740
4049769	Molybdenum salts,inorg acids	0	3	0	0
4049767	Molybenum disulphide	16	6	210	45
4096089	Monoacid derivatives nes	643	457	2132	872
4066420	Monochlorobenzene	17	13	9	8
4113420	Monoethanolamine	832	871	946	1002
4117877	Monolinuron,technical	16	15	193	178
4081329	Monophenols nes	580	418	1735	1520
4114520	Monosodium glutamate,bulk	2984	2752	6794	5255

SC code	Imported product	Volume (in mt)		Value (in $000)	
		1981	1982	1981	1982
4114540	Monosodium glutamate,pkg	197	166	419	303
4188853	Monuron,formulated herbicide	20	0	25	0
4135230	Morphine acetate,in bulk	0	0	0	0
4135290	Morphine derivatives	9	0	39	0
4135234	Morphine hydrobromide,bulk	0	0	0	0
4135236	Morphine hydrochloride	15	44	9	10
4135242	Morphine meconate,in bulk	0	0	0	0
4135244	Morphine methobromide	0	0	0	0
4135246	Morphine nitrate,in bulk	0	0	0	0
4135250	Morphine sulphate,in bulk	314	147	135	67
4135252	Morphine tartrate,in bulk	0	0	0	0
4135220	Morphine,in bulk	0	24	0	6
4126510	Morpholine	677	504	1595	1214
4189615	Mosquito coils,formulated	59	39	117	87
4131060	Multivitamin preparations	12	26	280	569
4083152	Musk ambrette	11	0	22	0
4079527	Myristyl alcohol	11	11	11	7
4115947	N,N-Diethyl-m-toluamine	102	106	818	875
4115914	N,N-Dimethylacetamide	61	141	114	311
4115933	N,N-Dimethylformamide	109	145	127	162
4129117	N-Acetylsulphanilamide	7	3	82	31
4112654	N-Alkylphenylenediamines	0	0	0	0
4112655	N-Alkyltolylenediiamines	0	3	0	8
4127623	N-Allyl hydroxymorphinan	0	0	1	0
4115915	N-Lauroylsarcosine sodium	3	3	8	6
4114914	N-Methylglucamine	8	7	125	127
4168925	N-P-K mixtures	4665	5542	1713	3653
4097931	N-octyl n-decyl phthalate	0	3	0	3
4112644	N-phenyl-p-phenylenediamine	256	310	1056	1357
4126331	N-t-Butylbenzothiazole	364	491	1749	2612
4185721	Nabam,formulated pesticide	13	0	33	0
4136356	Nafcillin sodium,in bulk	0	0	0	10
4184117	Naled,formulated pesticide	4	6	24	35
4127624	Nalidixic acid,in bulk	3	2	316	239
4132663	Nandrolone+derivs,in bulk	0	2	0	27
4063364	Naphthalene refined	1122	805	634	533
4298510	Naphthenic acids	796	489	808	517
4095845	Naphthoic acid	20	1	41	2
4081856	Naphthol sulphonic acids	8	7	44	1
4114932	Naphthol-8-amino-disulfonate	0	0	0	0
4117532	Naphthonitrile	0	0	0	0
4129570	Naphthosultam-2,4-disulph acid	0	0	0	0
4095742	Naphthyl benzoate	1	0	0	0
4135937	Narcotine,in bulk	297	198	10	7
4136467	Neomycins,in bulk	11	10	445	475
4004925	Neon	13	16	25	42
4079963	Neopentyl glycol	378	240	500	337
4221035	Neoprene latex	781	422	2065	1298

SC code	Imported product	Volume (in mt) 1981	Volume (in mt) 1982	Value (in $000) 1981	Value (in $000) 1982
4225040	Neoprene rubber	6511	4092	17210	12457
4131022	Niacin+niacinamide, bulk	283	283	1711	1763
4127631	Nialamide,in bulk	0	0	0	0
4049922	Nickel ammonium sulphate	14	1	13	0
4043721	Nickel carbonate	10	14	66	93
4033632	Nickel chloride	94	66	273	191
4090224	Nickel formate	6	4	2	4
4029955	Nickel oxides hydro+peroxides	21	2	169	1
4049779	Nickel salts,inorg acids	6	4	13	6
4049777	Nickel sulphamate	85	25	115	65
4038426	Nickel sulphate	921	550	1702	949
4135960	Nicotine, technical	12	0	1	0
4189535	Nicotine,formulated insect	0	1	0	8
4127414	Nikethamide,in bulk	1	1	4	3
4088942	Ninhydrin	1	7	1	1
4112566	Nitramine	0	5	0	20
4069969	Nitrated deriv hydrocarbons	84	56	148	96
4081879	Nitrated+nitrosated derivs	394	270	1921	1206
4019937	Nitric acid	623	441	155	122
4059869	Nitrides nes	13	11	17	15
4117590	Nitrile function cmpds	186	997	2292	8505
4225070	Nitrile rubber	1570	1893	3915	4134
4114976	Nitrilotriacetic acid	194	14	240	18
4069965	Nitrobenzene	1	1	2	2
4085842	Nitrobenzoic acid	10	6	1	12
4117523	Nitrobenzonitrile	0	0	0	0
4096081	Nitrobenzoyl chlorides	0	3	0	0
4156913	Nitrocellulose,explosive	75	123	149	307
4127757	Nitrofurantoin,in bulk	5	11	6	15
4127351	Nitrofurazone,in bulk	2	3	16	26
4004931	Nitrogen	8580	7820	713	697
4119910	Nitrogen function cmpds	391	453	1854	1914
4051024	Nitrogen oxychloride	4	0	1	0
4163910	Nitrogen solutions	13622	10782	2139	1800
4188977	Nitrogen,formulated herbicide	0	0	0	0
4168935	Nitrogen-P mixtures	727	3141	176	708
4164990	Nitrogenous fertilizers	2284	10681	1070	2305
4156961	Nitroglycerin	85	120	156	200
4109930	Nitroglycerin,pure,unmixed	0	0	0	0
4109932	Nitroglycol,pure,unmixed	0	0	0	0
4069949	Nitrohalogenated deriv	44	29	41	49
4117533	Nitrophenylacetonitrile	0	5	0	9
4069975	Nitrosulfonated deriv hydrcbns	43	5	26	8
4069966	Nitrotoluene	5	3	1	19
4009925	Nitrous oxide	285	241	277	176
4109939	Nitrous+nitric esters salts	13	27	141	253
4004939	Non-metal chemical elements	261	119	966	624
4095824	Nonanoic acid	108	219	195	425

SC code	Imported product	Volume (in mt) 1981	Volume (in mt) 1982	Value (in $000) 1981	Value (in $000) 1982
4063335	Nonene	2	0	1	0
4081327	Nonyl phenol	871	435	1030	545
4109927	Nonyl sulphate	6	0	1	0
4132671	Norethindrone,in bulk	0	1	570	345
4136447	Novobiocin,in bulk	0	0	0	0
4125443	Octamethyltrisiloxane	1	11	5	4
4063322	Octane	40	21	28	18
4077822	Octanol	70	29	75	31
4081326	Octyl phenol	174	174	304	285
4079522	Octyl-decyl alcohol	64	145	106	205
4116420	Octylbicycloheptdicarboxil	3	3	11	17
4136483	Oleandomycin,in bulk	0	0	0	0
4095215	Oleic acid	56	81	81	101
4025989	Oleic acid derivatives	22	0	40	0
4025259	Oleic acid esters nes	25	0	36	0
4095239	Oleic acid salts nes	6	1	9	2
4079532	Oleyl alcohol	56	28	142	67
4109926	Oleyl sulphate	0	0	0	0
4135490	Opium derivatives nes	53	0	39	0
4135420	Opium,in bulk	128	176	12	27
4139990	Organic chemicals nes	325	348	1209	1249
4123390	Organo-arsenic compounds	7	7	70	92
4125990	Organo-inorganic compounds	655	539	4588	2653
4124590	Organo-mercury compounds	1	8	5	5
4125489	Organo-silicon compounds	1112	763	6816	4765
4122989	Organo-sulphur compounds	833	877	8691	4371
4125972	Organotin compounds	296	287	3437	3358
4045040	Ortho-sodium silicate	13	0	6	0
4019941	Orthophosphoric acid	3566	17720	1537	6154
4083790	Other epoxide derivatives	239	103	1023	407
2179990	Other natural gums	2309	1709	6043	4829
4079969	Other polyhydrics(xylitol)	824	720	2396	2088
4185679	Other thiocarbamates	50	34	327	246
4136361	Oxacillin sodium,in bulk	1	1	6	86
4096210	Oxalic acid	759	230	634	169
4127724	Oxazepam,in bulk	1	2	163	212
4239925	Oxidized rubber resins	44	12	137	34
4127523	Oxycarboxin, technical	0	0	0	0
4051029	Oxychlorides of nonmetals	110	38	92	56
4135835	Oxycodone,in bulk	99	114	30	36
4126332	Oxydiethylene benzothiazoate	7	10	22	33
4004930	Oxygen	20824	10409	1773	974
4019929	Oxygen cmpds of nonmetals	467	505	300	305
4088959	Oxygen function ketones	16	122	117	253
4088979	Oxygen function quinones	25	7	156	14
4099989	Oxygen-function acid derivs	148	89	354	272
4099779	Oxygen-function acid salts	78	41	637	1662
4099969	Oxygen-function acid esters	2327	3854	33421	32649

SC code	Imported product	Volume (in mt) 1981	Volume (in mt) 1982	Value (in $000) 1981	Value (in $000) 1982
4099759	Oxygen-function acids	388	205	9816	8044
4114989	Oxygen-function amino cmpnd	2194	777	13806	15264
4135940	Oxymorphone,in bulk	0	0	0	0
4059985	Oxysulphides + chlorosulp	0	1	0	0
4136457	Oxytetracycline,in bulk	102	74	2897	2401
4235940	PVC resin scrap	2672	3849	850	1034
4059650	Palladium compounds	3219	199	74	88
4095814	Palmitic acid	15	20	29	38
4127645	Pamaquine,in bulk	0	0	0	0
4133013	Pancreatin,in bulk	3	5	85	143
4313014	Pancrelipase,in bulk	1	1	84	311
4127327	Pantolactone	0	0	0	0
4133065	Papain,in bulk	4	13	90	190
4135940	Papaverine,in bulk	495	300	11	7
4189135	Paradichlorobenzene,formulated	87	16	95	23
4084521	Paraformaldehyde	1387	1059	655	396
4085911	Paraldehyde	1	1	2	1
4188967	Paraquat,formulated herbicide	42	245	164	1004
4184050	Parathion,formulated pesticide	8	15	31	39
4109976	Parathion,technical	6	9	39	37
4109923	Pecyl sulphate	0	0	0	0
4136319	Penicillin G nes,in bulk	3	1	161	57
4136312	Penicillin G potassium	9	4	304	193
4136314	Penicillin G procaine	2694	51	1655	1756
4136313	Penicillin G sodium,bulk	1	6	44	20
4136321	Penicillin N,in bulk	0	0	0	0
4136322	Penicillin O,in bulk	0	0	0	0
4136324	Penicillin V,in bulk	7	13	364	663
4136389	Penicillin derivs nes,bulk	33	30	6190	5916
4136329	Penicillin nes,in bulk	3	2	275	112
4184044	Pentac,formulated pesticide	4	5	164	143
4081521	Pentachlorophenol	0	4	0	4
4079952	Pentaerythritol	18	324	29	483
4109931	Pentaerythritol t-nitrate	7	0	5	0
4063323	Pentane	2267	1186	827	501
4127751	Pentylenetetrazole,bulk	0	0	0	0
4133067	Pepsin,in bulk	6	2	86	49
4069847	Perchloropentacyclodecane	8	14	48	50
4127621	Perphenazine,in bulk	3	8	19	30
4184249	Pesticide,acetic acid org	37	108	64	200
4184029	Pesticide,arsenic base,form	144	87	978	605
4182090	Pesticide,botanical extra	9	58	100	348
4185649	Pesticide,carbamate base	157	627	2231	3626
4184049	Pesticide,chlorinated hydrde	0	1	0	4
4189889	Pesticide,formulated,nes	893	716	2752	2436
4182590	Pesticide,microbial,nes	36	34	62	54
4184129	Pesticide,phosphate base	32	19	76	66
4184079	Pesticide,phosphoro(thioa	839	2937	2415	8842

SC code	Imported product	Volume (in mt) 1981	Volume (in mt) 1982	Value (in $000) 1981	Value (in $000) 1982
4185790	Pesticide,thiocarbamates	595	717	1973	2833
4235529	Petroleum hydrocarbon resin	11343	9237	11518	11324
4127470	Phenazopyridine hydrochloride	1	1	60	22
4117825	Phenelzine+acid salts,bulk	0	0	0	0
4136351	Phenethicillin potassium	0	0	2	1
4079981	Phenethyl alcohol	33	30	60	74
4127460	Pheniramine,in bulk	1	5	33	53
4188981	Phenmedipham,formulated herb	26	63	255	858
4080110	Phenol	10432	5286	8310	3978
4099739	Phenol acids nes	13	1	96	4
4081886	Phenol-alcohol derivative	15	9	46	51
4081379	Phenol-alcohols nes	546	117	699	169
4230210	Phenol-formaldehyde resin	5746	6681	7894	8467
4232911	Phenol-resorcinol resins	369	39	214	59
4127976	Phenolphthalein,iin bulk	13	40	72	150
4129530	Phenolsulphonephthalein	0	5	0	4
4081850	Phenolsulphonic acid	160	0	111	0
4127973	Phenothiazine,bulk or tech	15	10	61	3
4118222	Phenyl isocyanate	152	5	324	14
4122041	Phenyl mercaptan	2	1	4	1
4124565	Phenyl mercury oleate	2	0	8	0
4097946	Phenyl phthalate	3	1	13	11
4099913	Phenyl salicylate	0	0	0	0
4085954	Phenylacetaldehyde	4	9	6	1
4095841	Phenylacetic acid	3	1	4	2
4123315	Phenylarsonic acid	7	0	98	0
4127312	Phenylbutazone,in bulk	6	4	213	92
4112642	Phenyldiamine derivatives	1	7	4	31
4112541	Phenylenediamine	14	8	63	36
4114981	Phenylephrine HCl	2	7	405	357
4124525	Phenylmercuric acetate	3	3	15	40
4124555	Phenylmercury borate	0	0	0	0
4114921	Phenylpropanolamine HCl	13	11	310	278
4095844	Phenylpropionic acid	4	4	0	0
4114935	Phenyltoloxamine	1	1	26	29
4127440	Phenyramidol,in bulk	0	5	0	24
4081353	Phloroglucinol	2	9	2	8
4184062	Phosalone,formulated pesticide	104	52	382	209
4184060	Phosmet,formulated pesticide	51	84	24	436
4115913	Phosphamidon technical	0	0	0	0
4184120	Phosphamidon,formulated pest	0	0	0	0
4165889	Phosphatic fertilizers nes	4835	5666	1334	1597
4165845	Phosphatic slag	35	25	10	6
4059839	Phosphides nes	216	119	227	117
4059987	Phosphonium iodide	0	3	0	1
4109959	Phosphoric ester,salts+dervs	639	370	1570	1210
4051035	Phosphorous pentachloride	33	11	52	27
4051036	Phosphorous trichloride	264	60	282	53

SC code	Imported product	Volume (in mt)		Value (in $000)	
		1981	1982	1981	1982
4004932	Phosphorus	1439	1788	2884	2603
4019945	Phosphorous acid	120	249	93	93
4051037	Phosphorous chlorides	3	0	5	0
4051023	Phosphorous oxychloride	7	6	30	55
4051084	Phosphorous pentasulphide	118	121	122	131
4019927	Phosphorous pentoxide	145	66	176	96
4051085	Phosphorous sulphides	2	1	11	1
4127814	Phthalazine	1	9	4	5
4098036	Phthalic acid	0	0	0	0
4097989	Phthalic acid derivatives	351	259	621	497
4097949	Phthalic acid esters nes	297	155	464	271
4097959	Phthalic acid salts nes	0	9	0	1
4097210	Phthalic anhydride	6398	3896	5852	3421
4116435	Phthalimide	0	2	0	7
4129120	Phthalylsulphathiazole	0	0	0	0
4135957	Physostigmine asalicylate	0	0	0	0
4135914	Physostigmine,in bulk	0	0	0	0
4188811	Picloram,formulated herb	577	658	4091	3005
4081877	Picric acid	3	4	5	17
4135913	Pilocarpine,in bulk	662	376	272	185
4136485	Pimafucin,in bulk	0	0	0	0
4063351	Pinene	77	70	84	48
4127420	Piperazine,in bulk	62	40	186	120
4084021	Piperonyl butoxide	20	13	248	112
4099757	Piperonylic acid	0	0	0	0
4185626	Pirimicarb,formulated pes	9	10	132	157
4168920	Plant food fertilizers prep	1756	1417	2445	1646
4189710	Plant growth regulators	247	191	1758	1290
4239989	Plastics materials	1636	882	7103	8249
4234440	Plastisol	682	2265	781	1515
4059640	Platinum compounds	151	152	63	75
4098089	Polyacid derivatives nes	388	197	1084	773
4098069	Polyacid esters nes	34	32	50	50
4098079	Polyacid salts nes	12	19	13	28
4231590	Polyamide resin nes	6603	4104	22159	16871
4235970	Polyamide resin scrap+waste	43	21	34	17
4225025	Polybutadiene rubber	17630	15392	24808	22395
4225027	Polybutene+polyisobutylene	427	257	448	227
4231110	Polycarbonate resins	4028	2831	14893	11483
4232989	Polycondensation+poly add	6235	4019	12144	8550
4231320	Polyesters,thermoplastic	4759	6768	12326	16984
4231330	Polyesters,thermosetting	2834	2607	7304	6110
4232959	Polyether resins nes	12427	11439	27321	27399
4233330	Polyethlene medium-density	2758	4011	4376	6360
4232950	Polyethylene glycol	1239	1327	3118	3394
4233340	Polyethylene high-density	35631	38701	42896	39847
4233320	Polyethylene low-density	26351	42443	28590	40673
4235930	Polyethylene resin scrap	475	1217	408	695

SC code	Imported product	Volume (in mt)		Value (in $000)	
		1981	1982	1981	1982
4225023	Polyisoprene rubber	3419	2353	6576	4479
4235589	Polymerization resins nes	12805	10854	17425	17143
4136630	Polymyxins,in bulk	1	1	151	156
4136690	Polypeptide antibiotics	0	3	0	15
4019943	Polyphosphoric acid	13192	8696	5022	3315
4232955	Polypropylene glycol	6118	8305	10709	12090
4235950	Polypropylene resin scrap	144	165	106	133
4235310	Polypropylene resins	15224	11944	17220	14992
4233727	Polystyrene molding cmpds	2117	838	2662	989
4233735	Polystyrene resin compounds	338	350	749	712
4235935	Polystyrene resin scrap+waste	181	44	151	33
4233725	Polystyrene resins	6422	5538	10786	9559
4233790	Polystyrene resins nes	9138	3301	10479	4495
4235920	Polysulfide resin scrap	2	6	10	23
4235567	Polysulfide resins	68	230	323	461
4225030	Polysulfide rubber	578	311	2401	1463
4235524	Polyterpene resins	802	1067	1471	1926
4129141	Polythiazide,in bulk	1	0	1	0
4235960	Polyurethane resin scrap	1084	619	968	487
4231810	Polyurethane resins	13981	5334	38195	17947
4234927	Polyvinyl acetal resins	174	124	285	212
4234510	Polyvinyl acetate resins	3722	3524	3612	3843
4234937	Polyvinyl alcohol resins	2970	2675	6677	5565
4234947	Polyvinyl butyral resins	191	126	511	429
4234430	Polyvinyl chloride disper	1991	2698	2457	2841
4234420	Polyvinyl chloride moldin	6981	6351	8880	8588
4234490	Polyvinyl chloride resins	21806	11465	22001	11791
4234815	Polyvinyl chloride-acetate	2082	1544	3473	3400
4234967	Polyvinyl ether resins	12	54	30	197
4234890	Polyvinyl resin copolymer	3210	2068	5057	4169
4234990	Polyvinyl resins nes	1891	1495	3544	3127
4235420	Polyvinyl-polystyrene resin	43	37	56	38
4234110	Polyvinylidene chloride resin	2160	1733	4771	4049
4083251	Potass guaiacol sulfonate	0	4	0	6
4069912	Potass toluene sulfonate	188	19	108	20
4090630	Potassium acetate	22	203	11	76
4120420	Potassium amyl xanthate	1285	608	1838	884
4095736	Potassium benzoate	0	0	0	0
4043735	Potassium bicarbonate	228	137	107	99
4047921	Potassium bichromate	56	44	104	100
4098421	Potassium bitartrate	97	114	207	187
4049817	Potassium bromide	109	130	253	414
4042110	Potassium carbonate	1265	1113	788	728
4034530	Potassium chlorate	432	413	432	375
4166410	Potassium chloride	8596	1881	1300	684
4096025	Potassium cinnamate	0	0	0	0
4099122	Potassium citrate	64	146	139	310
4044922	Potassium cyanide	130	68	285	133

SC code	Imported product	Volume (in mt)		Value (in $000)	
		1981	1982	1981	1982
4120431	Potassium ethyl xanthate	0	0	0	0
4044930	Potassium ferricyanide	51	20	166	50
4166990	Potassium fertilizers nes	1957	792	279	143
4031934	Potassium fluoborate	42	2	106	3
4031925	Potassium fluoride	176	171	334	206
4099763	Potassium gluconate	1	5	1	12
4059855	Potassium hydride	9	0	8	0
4099132	Potassium hydrogn citrate	0	45	0	15
4020910	Potassium hydroxide	3143	3407	2090	1776
4120426	Potassium isopropyl xanthate	9	0	9	0
4035920	Potassium metabisulphite	278	102	113	42
4038810	Potassium nitrate	2669	2445	1134	1096
4047931	Potassium permanganate	387	361	962	896
4021220	Potassium peroxide	0	0	0	0
4038475	Potassium persulphate	152	64	185	82
4040130	Potassium phosphate dibasic	438	565	350	485
4040140	Potassium phosphate tribasic	77	54	99	55
4040120	Potassium phosphate, mono	438	565	350	485
4040190	Potassium phosphates nes	698	557	812	703
4040150	Potassium pyrophosphate	109	109	125	118
4049819	Potassium salts,inorg acid	79	64	354	320
4045610	Potassium silicates	828	686	617	617
4168921	Potassium sodium nitrate	46	55	17	20
4098422	Potassium sodium tartrate	4	68	7	199
4096021	Potassium sorbate	253	283	1216	1373
4166610	Potassium sulfate 52% K2O	18288	20045	2653	3524
4038427	Potassium sulphate	3170	817	768	303
4098423	Potassium tartrate	13	10	29	18
4047952	Potassium titanate	57	25	92	43
4127684	Prazosin,in bulk	0	6	742	585
4059689	Precious metal compds	1071	1768	264	236
4132037	Prednisolone,in bulk	6	1	145	405
4132040	Prednisone,in bulk	7	12	412	559
4156969	Prepared explosives nes	0	0	3861	5764
4168990	Prepared fertilizer mixture	37552	36933	14731	13395
4115977	Prilocaine,in bulk	9	7	32	22
4127481	Primaclone,in bulk	4	4	182	201
4129116	Probenecid,in bulk	1	10	29	28
4114965	Procaine+its HCl,bulk	1	4	2	10
4127615	Prochlorperazine,in bulk	1	5	29	31
4132672	Progesterone,in bulk	0	3	4	14
4127720	Promazine,in bulk	1	2	13	14
4127641	Promethazine,in bulk	8	10	39	38
4188836	Prometryn,formulated herb	8	0	73	0
4188972	Propachlor,formulated herb	0	0	0	0
4114911	Propanolamines	703	713	951	1619
4114940	Propanolol+its HCl,bulk	11	12	2058	2198
4127747	Propantheline bromide,bulk	0	0	0	0

SC code	Imported product	Volume (in mt)		Value (in $000)	
		1981	1982	1981	1982
4156919	Propellent powders,nes	289	83	1525	803
4091015	Propionic acid	1430	1248	847	822
4091089	Propionic acid derivative	31	37	73	40
4091059	Propionic acid esters nes	8	3	1	10
4091029	Propionic acid salts nes	10	0	33	0
4091087	Propionyl peroxide	5	4	17	7
4114913	Propoxyphene+isomers,bulk	2	3	193	244
4112643	Propphenp-phenylenediamine	0	2	0	10
4090647	Propyl acetate+isopropyl	1806	1934	2018	2305
4079920	Propyl alcohol + isomers	2534	1950	1984	2180
4099921	Propyl gallate	27	3	101	68
4099927	Propyl p-hydroxybenzoate	20	23	88	113
4112525	Propylamine	231	234	277	307
4063331	Propylene	14937	1734	6404	817
4079962	Propylene glycol, mono	1522	4528	1439	3963
4083730	Propylene oxide	65	56	69	68
4112630	Propylenediamine	12	11	43	52
4239939	Protein,plastics nes	29	7	34	1
4085972	Protocatechualdehyde	0	0	0	0
4112565	Protriptyline+derivatives	2	1	33	22
4127416	Pyridine	45	73	270	258
4131024	Pyridoxine,in bulk	11	65	486	379
4127670	Pyrilamine,in bulk	3	1	107	37
4127647	Pyrimethamine,in bulk	0	0	1	0
4127456	Pyrithione+acid salts	101	71	3006	2036
4081355	Pyrocatechol	8	1	1	2
4081352	Pyrogallol	6	5	5	4
4019942	Pyrophosphoric acid	24	464	7	170
4127337	Pyrrole	1	1	7	0
4115279	Quaternary ammonium salts	170	110	395	253
4129143	Quinethazone,in bulk	0	0	0	0
5135970	Quinidine sulphate,in bulk	5	3	516	351
4135930	Quinidine,in bulk	1	1	56	163
4135920	Quinine,in bulk	5	3	428	323
4088969	Quinones nes	38	18	447	197
4127656	Quinoxalinylmethylenecarbamate	16	18	882	1021
4127775	Racemethorphan,in bulk	3	3	948	739
4052120	Radium	0	7	0	3
4052130	Radium compounds	54	3	29	467
4059749	Rare earth compounds	1852	307	3366	920
4059741	Rare earth silicide	220	523	673	1561
4009940	Rare earths	112	263	813	601
4004929	Rare gas elements nes	388	1308	1886	2083
4133979	Rennet,in bulk	124	52	1186	528
4135944	Reserpine,in bulk	9	0	14	0
4235830	Resins derived from natural	6510	3517	10869	6653
4081110	Resorcinol	565	346	2678	1782
4232919	Resorcinol resins nes	172	107	903	578

SC code	Imported product	Volume (in mt)		Value (in $000)	
		1981	1982	1981	1982
4232915	Resorcinol-formaldehyde resins	322	306	776	890
4059660	Rhodium compounds	15	18	45	13
4131020	Riboflavin,in bulk	52	65	2624	2802
4136481	Rifamycins,in bulk	11	6	622	355
4184133	Riogen,formulated pesticide	0	0	0	0
4189390	Rodenticides,formulated	156	120	414	353
4182040	Rodine,botanical base pest	0	0	0	0
4136546	Rolitetracycline dervis	1	0	74	0
4184061	Ronnel,formulated pesticide	0	5	0	1
4182030	Rotenone pesticide preparations	3	25	7	57
4239921	Rubber hydrochloride	7	17	1	81
4229010	Rubber,reclaimed	2512	3011	1961	2394
4235880	Run gums	6	27	10	47
4221030	SB latex	8610	6257	12411	10320
4116415	Saccharin	65	46	639	305
4081375	Salicyl alcohol	2	0	2	0
4129115	Salicylazosulphapyridine	2	3	107	142
4099731	Salicylic acid	60	30	145	55
4047989	Salts of metallic acids	161	75	673	342
4134025	Saponins,in bulk	2	3	6	8
4085929	Sat acyclic aldehydes nes	702	1292	717	1294
4079939	Saturated acyclic monohydride	100	96	380	414
4063329	Saturated acyclics	67	41	38	29
4059770	Scandium compounds	2	1	1	0
4135947	Scopolamine,in bulk	2	108	0	5
4004933	Selenium	3	4	87	89
4051022	Selenium oxychlorides	5	0	1	0
4114984	Serine	6	3	16	17
4016290	Silica gel nes	4319	3844	6782	6819
4016220	Silica gel, colloidal	732	715	2881	2580
4016230	Silica gel, hydrated	5101	4034	3973	3794
4059919	Silicides nes	293	54	923	183
4004937	Silicon	1233	1644	1818	617
4051034	Silicon chlorides	4	4	19	20
4059862	Silicon nitride	2	2	0	2
4051086	Silicon sulphides	1	0	5	0
4232310	Silicone resins	3363	2786	18880	16995
4125449	Siloxanes,nes	13	23	84	151
4059627	Silver amalgams	0	0	0	0
4059621	Silver bromide	0	0	0	0
4059622	Silver chloride	10	1	1	0
4059629	Silver compounds	1671	997	237	137
4059623	Silver cyanide	191	3	28	1
4059624	Silver iodide	63	8	11	2
4059625	Silver nitrate	832	542	83	38
5049626	Silver oxides	49	4	6	1
4188925	Silvex,formulated herbicide	24	0	39	0
4188831	Simazine,formulated herbicide	86	77	283	278

SC code	Imported product	Volume (in mt)		Value (in $000)	
		1981	1982	1981	1982
4085979	Single+complex oxygen-funct	319	4	780	8
4169920	Sludge,activated	2480	1505	238	142
4126315	Sodium mercaptobenzothiazole	11	55	21	89
4005110	Sodium	7923	7860	10783	12401
4090631	Sodium acetate	220	168	272	201
4039925	Sodium acid pyrophosphate	368	449	368	475
4047977	Sodium aluminate	315	108	398	93
4049921	Sodium aluminum phosphate	322	423	386	603
4038432	Sodium aluminum sulphate	175	126	188	133
4049826	Sodium arsenate	18	2	36	4
4184022	Sodium arsenate,formulated	0	2	0	7
4184023	Sodium arsenite,formulated	13	3	37	0
4059611	Sodium aurothiomalate	15	86	252	168
4059871	Sodium azide	0	2	0	1
4095734	Sodium benzoate	318	306	539	533
4041710	Sodium bicarbonate	15731	16168	5563	6329
4046610	Sodium bichromate	6726	5319	6968	5686
4036510	Sodium bisulphate	5430	4212	738	429
4035921	Sodium bisulphite	570	260	234	95
4045810	Sodium borate	46598	43951	11733	12130
4059852	Sodium borohydride	210	356	367	676
4120423	Sodium butyl xanthate	9	0	12	0
4041620	Sodium carbonate anhydride	138292	121673	15719	14840
4041640	Sodium carbonate decahydride	7	45	15	86
4041630	Sodium carbonate monohydride	348	240	41	34
4034520	Sodium chlorate	580	1262	141	388
4033930	Sodium chlorite	198	257	364	507
4047922	Sodium chromate	21	18	34	31
4096026	Sodium cinnamate	1	0	2	0
4099125	Sodium citrate	231	519	364	900
4044110	Sodium cyanide	5520	7078	7572	9918
4117531	Sodium dicyanamide	0	0	0	0
4121251	Sodium diethyldithiocarbamate	0	0	0	0
4121242	Sodium dimethyldithiocarbamate	11	0	1	0
4120427	Sodium ethyl xanthate	127	111	163	103
4031935	Sodium fluoborate	40	47	13	19
4031920	Sodium fluoride	318	376	317	382
4031930	Sodium fluoroaluminate	1563	3902	1723	2937
4090221	Sodium formate	529	365	224	165
4099764	Sodium gluconate	1286	1455	1457	2021
4109940	Sodium glycerophosphate	1	1	4	1
4059612	Sodium gold cyanide	0	0	0	0
4059854	Sodium hydride	1	2	1	2
4035510	Sodium hydrosulphide	1142	1131	391	459
4035620	Sodium hydrosulphite	7379	6849	7819	9371
4020610	Sodium hydroxide, dry	4920	3978	2526	2157
4020510	Sodium hydroxide, liquid	211044	168709	43272	34815
4033920	Sodium hypochlorite	789	731	134	84

SC code	Imported product	Volume (in mt)		Value (in $000)	
		1981	1982	1981	1982
4120425	Sodium isopropyl xanthate	999	1160	1104	1267
4035922	Sodium metabisulphite	2745	2452	734	721
4039924	Sodium metaphosphate	65	21	105	35
4139935	Sodium methoxide	45	33	127	113
4047962	Sodium molybdate	14	37	64	238
4081855	Sodium naphtholsulphonate	4	15	7	26
4039132	Sodium nitrate	6946	10115	1975	2450
4163310	Sodium nitrate under 16%N	11689	5571	2724	1254
4114977	Sodium nitrilotriacetate	22571	18667	25851	25299
4039120	Sodium nitrite	3734	2932	1401	890
4081527	Sodium pentachlorophenate	15	0	20	0
4049827	Sodium perborate	1078	839	960	657
4021230	Sodium peroxide	7	7	4	4
4038473	Sodium persulphate	152	369	546	426
4039921	Sodium phosphate,dibasic	279	329	233	307
4039923	Sodium phosphate,mono	753	346	506	319
4039510	Sodium phosphate,tribasic	646	336	326	367
4039990	Sodium phosphates nes	969	442	1013	512
4091023	Sodium propionate	4	7	7	13
4079765	Sodium salicylate	8	11	21	24
4049829	Sodium salts,inorg acids	241	362	566	754
4041910	Sodium sesquicarbonate	6453	8155	736	889
4045020	Sodium silicate	2862	2526	1428	1192
4047941	Sodium stannate	1	10	0	4
4036210	Sodium sulphate	12480	17293	756	1341
4035420	Sodium sulphide	966	656	388	222
4035810	Sodium sulphite	7036	4806	1872	1641
4035630	Sodium sulphoxylates	111	94	210	206
4035422	Sodium tetrasulphide	66	23	21	7
4035931	Sodium thiosulphate	439	209	386	137
4047953	Sodium titanate	97	84	163	112
4096011	Sodium trichloracetate	522	759	810	1292
4039922	Sodium tripolyphosphate	1387	1546	1276	1563
4047912	Sodium tungstate	17	13	39	38
4115956	Solan, technical	0	0	0	0
4188976	Solan,formulated herbicide	0	4	0	1
4095830	Sorbic acid	171	250	865	1252
4079957	Sorbitol	8243	8196	7741	7083
4135935	Sparteine sulphate,in bulk	0	0	0	0
3944920	Spermaceti wax	6	8	14	20
4136475	Spiramycins,in bulk	7	1	111	108
4127652	Spironolactone,in bulk	2	2	1893	1281
4031936	Stannous fluoborate	35	44	213	276
4031924	Stannous fluoride	6	7	86	62
4049847	Stannous pyrophosphate	0	0	0	0
4038416	Stannous sulphate	19	4	93	49
4239950	Starch,esterified/etherified	2191	2720	2197	2552
4094215	Stearic acid	420	497	473	514

SC code	Imported product	Volume (in mt) 1981	Volume (in mt) 1982	Value (in $000) 1981	Value (in $000) 1982
4094289	Stearic acid derivatives	110	152	167	282
4094259	Stearic acid esters nes	51	74	113	147
4094239	Stearic acid salts nes	22	65	186	190
4079534	Stearyl alcohol	108	63	226	137
4109922	Stearyl sulphate	0	0	0	0
4136490	Streptomyces,derivs nes	563	443	4364	5595
4136415	Streptomycin,in bulk	52	29	375	377
4136440	Streptovaricins,in bulk	1	1	1433	1113
4053244	Strontium 90	6	7	28	30
4021945	Strontium hydroxide	87	6	13	3
4098222	Strontium lactate	0	0	0	0
4021940	Strontium oxide	25	4	18	3
4021947	Strontium peroxide	5	1	15	3
4049839	Strontium salts,inorg acid	5	31	13	49
4233690	Styrene copolymers nes	592	439	822	653
4063365	Styrene monomer	2966	610	2353	443
4233625	Styrene-acrylonitrile-res	2756	1226	4438	2348
4233615	Styrene-butadiene resins	11590	5780	15806	11024
4225045	Styrene-butadiene rubber	22216	19551	29852	26389
4233640	Styrene-maleic copolymer	4472	3003	6698	5468
4098012	Succinic acid	27	1	16	1
4116430	Succinimide	1	1	2	0
4098052	Succinyl chloride	0	0	0	0
4115135	Succinylcholine chloride	7	8	12	18
4129121	Succinylsulphathiazole	0	3	0	4
4099733	Sulfosalicylic acid	10	1	21	11
4009926	Sulfur dioxide	1154	7453	284	2001
4004934	Sulfur, sublimed	79	7	43	6
4004935	Sulfur,collodial	342	1034	209	653
4011510	Sulfuric acid plus oleum	82495	192581	31767	9080
4129122	Sulphadiazine,in bulk	7	4	74	40
4129123	Sulphadimethoxine,bulk	6	10	52	98
4129124	Sulphamethizole,in bulk	4	4	50	134
4129125	Sulphamethoxazole,bulk	35	29	1212	983
4129127	Sulphamethoxypyridazine	0	1	0	10
4019936	Sulphamic acid	1170	439	895	393
4166920	Sulphate of potash-magnesium	51000	56958	5564	6118
4129126	Sulphathiazole,in bulk	19	12	198	100
4129130	Sulphisoxazole,in bulk	1	2	35	64
4069934	Sulphohalogenated deriv	8	4	2215	146
4129190	Sulphonamides nes,in bulk	263	309	9909	10874
4069919	Sulphonated derivatives	531	489	970	653
4081859	Sulphonated derivatives	22	11	118	30
4051089	Sulphur compds of nonmetal	238	118	418	250
4051055	Sulphur hexafluoride	141	125	1111	1124
4109929	Sulphuric ester salts+dervs	527	434	425	336
4051026	Sulphuryl chloride	1471	1201	1107	915
4129579	Sultams nes,in bulk	8	5	23	0

SC code	Imported product	Volume (in mt) 1981	Volume (in mt) 1982	Value (in $000) 1981	Value (in $000) 1982
4129559	Sultones nes,in bulk	20	1	18	2
4165510	Superphosphate > 22% P205	38193	31948	8195	7143
4165410	Superphosphate,22%or less	3680	188	184	56
4235990	Synthetic resin scrap+waste	616	512	586	491
4239929	Synthetic resins derived	361	299	495	343
4235890	Synthetic resins from natural	1794	1361	3245	2274
4225090	Synthetic rubber nes	1359	6744	3143	11605
4235820	Tall oil synthetic resins	96	24	216	34
3969922	Tannic acid	41	27	68	145
4098415	Tartaric acid	276	171	1024	390
4098489	Tartaric acid derivatives	2	2	3	4
4098439	Tartaric acid esters nes	0	0	0	0
4098429	Tartaric acid salts nes	0	0	0	0
4127662	Tavegil,in bulk	6	2	5245	2752
4188856	Tebuthiuron,formulated herb	93	49	355	307
4184055	Temophos,formulated pest	0	1	0	25
4122952	Temophos,technical	8	1	121	18
4188986	Terbacil,formulated herb	1	15	23	311
4079973	Terpineol	41	33	48	45
4090654	Terpinyl acetate	17	6	31	13
4132661	Testosterone,in bulk	6	5	52	44
4125981	Tetra(hyroxymethyl)phosphon Cl	0	0	0	0
4098084	Tetrabromophthalic anhydride	38	16	61	28
4069843	Tetrachloroethylene,bulk	717	2292	341	1003
4098083	Tetrachlorophthalic anhydride	0	0	0	0
4136590	Tetracycline deriv nes	9	4	525	349
4136515	Tetracycline,in bulk	38	50	1200	1526
4109966	Tetraethyl orthocarbonate	0	0	0	0
4125960	Tetraethyl-lead	2	0	0	0
4112616	Tetraethylenepentamine	88	48	282	164
4122932	Tetraethylthiuram disulph	2	2	4	12
4127315	Tetrahydrofuran	427	399	983	1010
4127626	Tetrahydrozoline,in bulk	0	15	0	48
4115269	Tetramethyl ammonium salt	0	2	0	0
4125961	Tetramethyl-lead	0	0	0	0
4115265	Tetramethylammoniumformat	0	0	0	0
4115264	Tetramethylammoniumhydrox	3	3	0	0
4115263	Tetramethylammoniumiodide	0	0	0	0
4112614	Tetramethyldiaminobutane	1	0	2	0
4122930	Tetramethylthiuram disulph	216	131	441	201
4122931	Tetramethylthiuram monosulf	35	44	126	172
4039920	Tetrasodium pyrophosphate	295	254	284	262
4127642	Thenaldine,in bulk	0	0	0	0
4127666	Thenyldiamine,in bulk	2	1	6	0
4135932	Theobromine,in bulk	0	0	0	0
4135941	Theophylline,in bulk	6	2	77	30
4127820	Thiabendazole,bulk or tech	4	1	91	8
4185841	Thiabendazole,formulated	0	0	0	0

SC code	Imported product	Volume (in mt) 1981	Volume (in mt) 1982	Value (in $000) 1981	Value (in $000) 1982
4131016	Thiamine,in bulk	26	25	964	916
4122973	Thiamylal,in bulk	1	0	30	0
4126389	Thiazoles nes	8	1	33	7
4127637	Thiethylperazine,in bulk	0	1	12	17
4122979	Thioaldehydes,thioketones	287	440	1465	2232
4122929	Thioamides nes	8	37	39	118
4121390	Thiocarbamates nes	94	8	272	1
4122974	Thioglycollic acid	148	130	386	317
4122975	Thiolactic acid	34	1	124	3
4184065	Thionazin,formulated pest	0	0	0	0
4051027	Thionyl chloride	223	171	238	193
4122926	Thiopental sodium,bulk	1	2	15	79
4127353	Thiophan sulfone	376	189	1399	762
4127717	Thioridazine,in bulk	1	2	513	803
4122020	Thiosalicylic acid	3	0	5	0
4122920	Thiourea	168	102	342	244
4122939	Thiuram sulphides nes	0	0	0	0
4059757	Thorium carbide	0	0	0	0
4059754	Thorium chloride	0	0	0	0
4059751	Thorium dioxide	1	1	38	31
4059752	Thorium nitrate	40	20	305	175
4059759	Thorium salts + compounds nes	1	0	5	0
4059756	Thorium sulphate	0	1	0	0
4081323	Thymol	21	8	17	18
4129540	Thymolsulphonephthalein	0	0	0	0
4127962	Timolol maleate	1	101	1478	776
4033633	Tin chlorides	141	132	1471	1381
4029954	Tin oxides hydrox+peroxides	12	21	69	158
4059836	Tin phosphide	0	0	0	0
4049849	Tin salts,inorg acids	0	0	0	0
4024810	Titanium dioxide, pure	6985	5737	11377	9892
4049859	Titanium salts,inorg acids	63	4	88	9
4033635	Titanium tetrachloride	1596	1452	1395	1538
4129151	Tolazamide,in bulk	0	1	0	1
4129147	Tolbutamide,in bulk	5	17	33	159
4062210	Toluene	4095	1135	1750	472
4118212	Toluene 2,4-diisocyanate	15330	13642	31383	29703
4112653	Toluene-2,4-diamine	7	4	21	11
4112556	Toluidine isomer derivatives	2081	2945	14152	25068
4112555	Toluidine isomers	11	13	65	47
4127454	Toxopyrimidine	35	0	336	0
4112671	Tranylcypromine	1	27	23	67
4109956	Tri-(2-butoxyethyl)phosph	201	220	669	746
4121335	Triallate, technical	3427	3129	29012	28115
4185652	Triallate,formulated pest	21954	24958	30721	45276
4132041	Triamcinolone,in bulk	1	8	2487	1904
4127672	Triamterene,in bulk	11	8	1218	740
4109947	Tributyl phosphate	5	3	17	8

SC code	Imported product	Volume (in mt)		Value (in $000)	
		1981	1982	1981	1982
4125971	Tributyltin oxide	30	12	402	236
4040640	Tricalcium phosphate	1769	3370	1006	1571
4095822	Trichloroacetic acid	3	8	5	13
4069862	Trichlorobenzene	71	28	83	37
4065310	Trichloroethylene	1253	1877	835	1172
4065923	Trichlorofluoromethane	21	11	26	16
4127426	Trichloroisocyanuric acid	439	434	1282	1485
4081522	Trichlorophenol	1	0	1	0
4065933	Trichlorotrifluoroethane	135	185	266	484
4189515	Trichlorphon,formulated	14	64	49	169
4125983	Trichlorphon,technical	17	12	319	100
4105210	Tricresyl phosphate	64	39	145	90
4079531	Tridecanol	804	714	1158	1052
4083233	Trieth glycol monbutether	0	0	0	0
4083235	Trieth glycol monmethether	0	0	0	0
4083234	Trieth glycol monoethether	0	0	0	0
4113440	Triethanolamine	824	926	1029	983
4125965	Triethylaluminum	19	37	104	207
4112526	Triethylamine	207	155	435	327
4083214	Triethylene glycol	1193	1089	1411	1116
4112615	Triethylene tetramine	88	48	282	164
4127816	Triethylenediamine	26	10	94	58
4125433	Triethylsilanol	0	0	0	0
4127713	Triflupromazine,in bulk	1	9	3	24
4188985	Trifluralin,formulated herb	13	261	17	1234
4098035	Trimellitic acid	0	0	0	0
4098082	Trimellitic anhydride	803	699	1507	1458
4127654	Trimethoprim,in bulk	5	8	2131	1912
4112527	Trimethylamine	39	9	86	27
4078210	Trimethylolethane	517	425	939	802
4079965	Trimethylolpropane	491	427	909	854
4127737	Trimipramine,in bulk	1	1	590	684
4069967	Trinitrodimethyltbutylbenzene	8	9	19	27
4156962	Trinitrotoluene,prepared	0	9	0	11
4069963	Trinitrotoluol	3	0	5	0
4114982	Triparanol	0	0	0	0
4127430	Tripelennamine,in bulk	2	3	394	52
4083236	Tripentaerythritol	36	35	61	41
4109946	Triphenyl phosphate	9	54	27	152
4109974	Triphenyl phosphite	58	30	125	62
4125435	Triphenylsilanol	0	0	0	0
4127664	Triprolidine,in bulk	6	2	236	157
4109952	Tris 2,3dibromo phosphate	11	11	25	22
4133015	Trypsin,in bulk	10	1	26	1
4136640	Tyrocidines,in bulk	0	0	0	0
4115953	Tyropanoate sodium,bulk	1	6	4	46
4136635	Tyrothricin,in bulk	5	5	9	9
4127914	Umbelliferone	0	0	0	0

SC code	Imported product	Volume (in mt)		Value (in $000)	
		1981	1982	1981	1982
4095827	Undecanoic acid	9	6	56	42
4095832	Undecenoic acid	1	2	1	3
4085939	Unsat acyclic aldehydes	4	5	15	9
4079949	Unsaturated acyclic mono	12	25	64	22
4063330	Unsaturated acyclics	429	314	593	363
4053243	Uranium metal radioactive	1	171	6291	6725
4053224	Uranyl nitrate	1	1	6	1
4163110	Urea	93900	100981	24887	24769
4059816	Urea hydrogen peroxide	0	174	0	183
4230910	Urea-aldehyde resins	5249	3206	6442	4093
4095813	Valeric acid	7	1	0	0
4029960	Vanadium oxides hydr pero	1392	1041	10888	7498
4136453	Vancomycin,in bulk	3	1	43	268
4085610	Vanillin	11	64	122	612
4135890	Vegetable alkaloids,narco	9	63	0	2
4135990	Vegetable alkaloids,nes	3	82	26166	35128
3999969	Vegetable extracts nes	885	680	3113	3521
4185655	Vernolate,formulated pest	10	15	55	116
4135923	Vinblastine sulphate,bulk	0	0	0	0
4135924	Vincristine,in bulk	35	0	147	0
4090645	Vinyl acetate	351	734	233	510
4069844	Vinyl chloride monomer	19198	7	9931	3
4096031	Vinyl chloroacetate	37	0	44	0
4083722	Vinylcyclohexene dioxide	0	0	0	0
4069841	Vinylidene chloride	0	0	0	0
4063363	Vinyltoluene	199	159	321	256
4136471	Viomycin,in bulk	0	0	0	0
4131014	Vitamin A,in bulk	34	24	1007	831
4131032	Vitamin B-12 complex,bulk	1	8	48	66
4131030	Vitamin B-12, in bulk	11	12	211	228
4131034	Vitamin C, in bulk	861	882	9746	10805
4131036	Vitamin D, in bulk	7	34	174	291
4131040	Vitamin E, in bulk	292	173	10966	6502
4131042	Vitamin K, in bulk	7	20	149	269
4131049	Vitamin nes, in bulk	378	262	3292	3252
4131070	Vitamin-other supplement	36	27	405	494
4127915	Warfarin,bulk or technical	2	1	13	9
4189315	Warfarin,formulated rodenticide	5	5	9	12
4120490	Xanthates nes	26	47	31	51
4135926	Xanthinol niacinate,bulk	2	1	207	97
4062310	Xylene	9922	166	5120	204
4081320	Xylenol + isomers	62	2	75	30
4081321	Xylenol mixed isomers	0	0	0	0
4127686	Xylometazoline,in bulk	0	3	430	423
4059760	Yttrium compds organic or	9	3	4	29
4049971	Zinc amalgam	1	0	0	0
4049920	Zinc ammonium chloride	1074	1044	910	1009
4043730	Zinc carbonate	26	2	36	4

SC code	Imported product	Volume (in mt)		Value (in $000)	
		1981	1982	1981	1982
4033634	Zinc chloride	1277	992	712	572
4044923	Zinc cyanide	47	16	138	41
4121235	Zinc dibutyldithiocarbamate	0	7	0	21
4121252	Zinc diethyldithiocarbamate	6	0	1	0
4121243	Zinc dimethyldithiocarbamate	8	0	1	0
4035621	Zinc hydrosulphite	0	2	0	3
4098224	Zinc lactate	0	0	0	0
4095021	Zinc laurate	0	0	0	0
4298726	Zinc naphthenate	0	0	0	0
4023220	Zinc oxide	1267	1348	1573	1487
4081857	Zinc p-phenol sulphonate	6	4	16	17
4022130	Zinc peroxide	36	18	192	107
4059834	Zinc phosphide	6	10	29	25
4049869	Zinc salts,inorganic acids	113	37	164	67
4094227	Zinc stearate	166	97	253	170
4037110	Zinc sulphate	1660	1966	710	827
4035632	Zinc sulphoxylates	41	25	62	42
4185722	Zineb,formulated pesticide	53	103	106	178
4121261	Zineb,technical	0	0	0	0
4059846	Zirconium carbide	1	0	0	0
4029965	Zirconium oxides	12	21	69	158
4045725	Zirconium silicate	1281	876	684	577
4115912	a-Bromoisovaleryl urea	0	0	0	0
4112553	a-Naphthylamine+derivs	15	26	53	127
4115946	a-Phenylacetamide	0	2	0	7
4063360	alpha-Methylstyrene	221	230	202	254
4081325	b-Naphthol	210	51	348	83
4112454	b-Naphthylamine+derivatives	147	124	761	678
4112542	d-Amphetamine sulfate	0	0	0	0
4080330	m-Cresol	6	7	12	10
4066440	m-Dichlorobenzene	0	2	0	2
4114330	m-Phenetidine	0	0	0	0
4098054	n-Octyl n-decyl adipate	0	0	0	0
4114972	o-Aminobenzoic acid	5	18	107	46
4080320	o-Cresol	349	17	633	41
4066430	o-Dichlorobenzene	187	186	141	178
4115972	o-Isopropyl n-phenyl carbamate	0	0	0	0
4114320	o-Phenetidine	5	0	1	0
4116444	o-Tolyldiguanide	3	2	14	3
4112657	p-Aminodiphenylamine	275	194	1052	772
4123322	p-Aminophenylarsonic acid	0	0	0	0
4114983	p-Aminosalicylic acid	2	0	5	0
4117761	p-Azoxyanisole	0	0	0	0
4081523	p-Chloro-m-xylenol	17	14	174	147
4081524	p-Chloro-o-cresol	0	0	0	0
4081520	p-Chlorophenol	734	574	1502	1343
4080340	p-Cresol	212	38	726	124
4117712	p-Diazobenzenesulphonic	0	0	0	0

SC code	Imported product	Volume (in mt)		Value (in $000)	
		1981	1982	1981	1982
4066450	p-Dichlorobenzene technical	3637	2457	3611	2385
4099734	p-Hydroxybenzoic acid	13	2	78	9
4127636	p-Hydroxyphenylbutazone	1	1	244	254
4083263	p-Menthane hydroperoxide	135	83	419	261
4114340	p-Phenitidine	0	0	0	0
4081324	p-Phenylphenol	18	17	77	73
4098037	p-Phthalic acid	7	28	8	31
4109967	t-Butylperoxy i-propylcarbamate	5	7	90	121
4083267	tert-Butyl hydroperoxide	126	76	218	137

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